

**Distribution, Abundance,
Population Structure, and
Meat Yield of the Ocean Quahaug
(*Arctica islandica*) and
Stimpson's Surf Clam (*Spisula
polynyma*) on the Scotian Shelf
and Georges Bank**

D.R. Chaisson¹ and T.W. Rowell²

¹Bio-Atlantech Limited
P.O. Box 2907 D.E.P.S.
Dartmouth, Nova Scotia
B2W 4Y2

²Fisheries Research Branch
Scotia-Fundy Region
Halifax Fisheries Research Laboratory
Department of Fisheries and Oceans
Halifax, Nova Scotia
B3J 2S7

February 1985

**Canadian Industry Report of
Fisheries and Aquatic Sciences
155**

Canadian Industry Report of Fisheries and Aquatic Sciences

Industry reports contain the results of research and development useful to industry for either immediate or future application. They are directed primarily toward individuals in the primary and secondary sectors of the fishing and marine industries. No restriction is placed on subject matter and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Industry reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1-91 in this series were issued as Project Reports of the Industrial Development Branch, Technical Reports of the Industrial Development Branch, and Technical Reports of the Fisherman's Service Branch. Numbers 92-110 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Industry Reports. The current series name was changed with report number 111.

Industry reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport canadien à l'industrie sur les sciences halieutiques et aquatiques

Les rapports à l'industrie contiennent les résultats des activités de recherche et de développement qui peuvent être utiles à l'industrie pour des applications immédiates ou futures. Ils sont surtout destinés aux membres des secteurs primaire et secondaire de l'industrie des pêches et de la mer. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports à l'industrie peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports à l'industrie sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 91 de cette série ont été publiés à titre de rapports sur les travaux de la Direction du développement industriel, de rapports techniques de la Direction du développement industriel, et de rapports techniques de la Direction des services aux pêcheurs. Les numéros 92 à 110 sont parus à titre de rapports à l'industrie du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 111.

Les rapports à l'industrie sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Industry Report of
Fisheries and Aquatic Sciences 155

February 1985

DISTRIBUTION, ABUNDANCE, POPULATION STRUCTURE, AND
MEAT YIELD OF THE OCEAN QUAHAUG (ARCTICA ISLANDICA) AND
STIMPSON'S SURF CLAM (SPISULA POLYNOMA) ON THE
SCOTIAN SHELF AND GEORGES BANK

by

D.R. Chaisson¹ and T.W. Rowell²

¹Bio-Atlantech Limited

P.O. Box 2907 D.E.P.S.

Dartmouth, Nova Scotia

B2W 4Y2

²Fisheries Research Branch

Scotia-Fundy Region

Halifax Fisheries Research Laboratory

Department of Fisheries and Oceans

Halifax, Nova Scotia

B3J 2S7

(c) Minister of Supply and Services Canada 1985

Cat. No. Fs 97-14/155E

ISSN 0704-3694

Correct citation for this publication:

Chaisson, D.R. and T.W. Rowell. 1985. Distribution, abundance, population structure, and meat yield of the ocean quahaug (Arctica islandica) and Stimpson's surf clam (Spisula polynyma) on the Scotian Shelf and Georges Bank. Can. Ind. Rep. Fish. Aquat. Sci. 155: ix + 125 p.

CONTENTS

List of tables	iv
List of figures	iv
Abstract	viii
Résumé	ix
Introduction	1
Materials and methods	2
Materials	2
Methods	2
Results	3
Previously unreported surveys	3
St. Anns Bank	3
Georges Bank	4
Population structure and meat yield	5
Western and Sable Island Banks	5
Banquereau Bank	5
Emerald Bank	6
Middle Bank	6
Near-shore area	6
Browns Bank	7
Roseway Bank	7
Inshore areas	7
Discussion	8
Resource	8
St. Anns Bank	8
Georges Bank	8
Population structure and meat yield	9
Industry overview	10
Catch rates	10
U.S. clam industry	11
Potential for a Canadian fishery	12
Conclusions	13
Acknowledgements	14
References	14

LIST OF TABLES

Table

1. Density and biomass of ocean quahaugs in High-Density Areas 1, 2, and 3 of Georges Bank	17
2. Estimates of maximum sustainable yield (MSY) in metric tons for <u>Arctica islandica</u> at various rates of natural mortality	19
3. Mean length, mean meat yield, and the percentage of animals in each of three commercial size classes for ocean quahaugs from areas on Western and Sable Island Banks	21
4. Mean length, mean meat yield, and the percentage of animals in each of three commercial size classes for ocean quahaugs from seven inshore areas	23
5. Station locations, 1980-1983	25

LIST OF FIGURES

Figure

1. Location of acoustical stations along the eastern shore of Nova Scotia (No. 1-9) and station locations preselected for dredge sampling on St. Anns Bank (No. 1-52)	43
2. Location of stations surveyed on St. Anns Bank showing densities (kg/m ²) of <u>A. islandica</u>	45
3. Locations of stations surveyed on St. Anns Bank showing densities (kg/m ²) of <u>S. polynyma</u>	47
4. Location of stations surveyed on Georges Bank in 1980, 1981, 1982, and 1983	49
5. Location of stations surveyed on Georges Bank showing densities (kg/m ²) of <u>S. solidissima</u> and <u>S. polynyma</u>	51
6. Location of stations surveyed on Georges Bank showing densities (kg/m ²) of <u>A. islandica</u> and boundaries of High-Catch Areas 1, 2, and 3	53
7. Length frequency (n=4268), cumulative percent frequency, and percent meat yield (n=94) for each 5 mm size class of <u>A. islandica</u> on Georges Bank	55

Figure

8.	Location of stations surveyed on Western and Sable Island Banks in 1981-1982 and boundaries of areas having greatest concentrations of <u>A. islandica</u>	57
9.	Length frequency (n=637), cumulative percent frequency, and percent meat yield (n=71) for each 5 mm size class of <u>A. islandica</u> in Area 1 of Sable Island Bank	59
10.	Length frequency (n=1228), cumulative percent frequency, and percent meat yield (n=139) for each 5 mm size class of <u>A. islandica</u> in Area 2 of Western Bank	61
11.	Length frequency (n=541), cumulative percent frequency, and percent meat yield (n=81) for each 5 mm size class of <u>A. islandica</u> in Area 3 of Western Bank	63
12.	Length frequency (n=1302), cumulative percent frequency, and percent meat yield (n=129) for each 5 mm size class of <u>A. islandica</u> in Area 4 of Sable Island Bank	65
13.	Length frequency (n=6253), cumulative percent frequency, and percent meat yield (n=492) for each 5 mm size class of <u>A. islandica</u> in Area 5 of Sable Island Bank	67
14.	Length frequency (n=850), cumulative percent frequency, and percent meat yield (n=111) for each 5 mm size class of <u>A. islandica</u> in Area 6 of Sable Island Bank	69
15.	Location of stations surveyed on Western and Sable Island Banks in 1981 and 1982 showing densities (kg/m ²) of <u>S. polynyma</u>	71
16.	Length frequency (n=149), cumulative percent frequency, and percent meat yield (n=73) for each 5 mm size class of <u>S. polynyma</u> on Western and Sable Island Banks	73
17.	Location of stations surveyed on Banquereau Bank in 1981-82 showing the boundaries of areas having the most significant concentrations of <u>S. polynyma</u>	75
18.	Length frequency (n=1922), cumulative percent frequency, and percent meat yield (n=487) for each 5 mm size class of <u>S. polynyma</u> in Area 1 of Banquereau Bank	77

Figure

19.	Length frequency (n=380), cumulative percent frequency, and percent meat yield (n=63) for each 5 mm size class of <u>S. polynyma</u> in Area 2 of Banquereau Bank	79
20.	Location of stations surveyed on Banquereau Bank in 1981-1982 showing densities (kg/m ²) of <u>A. islandica</u> . . .	81
21.	Length frequency (n=461), cumulative percent frequency, and percent meat yield for each 5 mm size class of <u>A. islandica</u> on Banquereau Bank.	83
22a.	Location of stations surveyed on Emerald Bank in 1981. .	85
22b.	Location of stations surveyed on Middle Bank in 1981-1982	85
23a.	Location of stations surveyed on Emerald Bank showing densities (kg/m ²) of <u>A. islandica</u>	87
23b.	Location of stations surveyed on Emerald Bank showing densities (kg/m ²) of <u>S. polynyma</u>	87
24a.	Location of stations surveyed on Middle Bank showing densities (kg/m ²) of <u>A. islandica</u>	89
24b.	Location of stations surveyed on Middle Bank showing densities (kg/m ²) of <u>S. polynyma</u>	89
25.	Length frequency (n=894), cumulative percent frequency, and percent meat yield (n=334) for each 5 mm size class of <u>A. islandica</u> on Middle Bank	91
26.	Length frequency, (n=583), cumulative percent frequency, and percent meat yield (n=57) for each 5 mm size class of <u>S. polynyma</u> on Middle Bank.	93
27.	Location of stations surveyed on Browns Bank, Roseway Bank, and the near-shore area in 1980	95
28.	Location of stations surveyed on Browns Bank, Roseway Bank, and the near-shore area showing densities (kg/m ²) of <u>A. islandica</u>	97
29.	Length frequency (n=221), cumulative percent frequency, and percent meat yield (n=218) for each 5 mm size class of <u>A. islandica</u> on the near-shore area	99
30.	Location of stations surveyed on Browns Bank, Roseway Bank, and the near-shore area showing densities (kg/m ²) of <u>S. polynyma</u>	101

Figure

31. Length frequency (n=130), cumulative percent frequency, and percent meat yield (n=95) for each 5 mm size class of S. polynyma on the near-shore area 103
32. Length frequency (n=172), cumulative percent frequency, and percent meat yield (n=83) for each 5 mm size class of S. polynyma on Browns Bank 105
33. Length frequency (n=83), cumulative percent frequency, and percent meat yield for each 5 mm size class of A. islandica on Roseway Bank 107
34. Length frequency (n=180), cumulative percent frequency, and percent meat yield (n=35) for each 5 mm size class of S. polynyma on Roseway Bank 109
35. Location of inshore areas having the greatest potential for commercial development of A. islandica 111
36. Length frequency (n=245), cumulative percent frequency, and percent meat yield (n=58) for each 5 mm size class of A. islandica from the 1982 LaHave survey 113
37. Length frequency (n=1072), cumulative percent frequency, and percent meat yield (n=315) for each 5 mm size class of A. islandica from the 1981 Jordan Bay survey 115
38. Length frequency (n=2204), cumulative percent frequency, and percent meat yield (n=261) for each 5 mm size class of A. islandica from the 1982 Shelburne Harbour survey . 117
39. Length frequency (n=453), cumulative percent frequency, and percent meat yield (n=93) for each 5 mm size class of A. islandica from the 1982 Negro Harbour survey . . . 119
40. Length frequency (n=1289), cumulative percent frequency, and percent meat yield (n=172) for each 5 mm size class of A. islandica from the 1981 and 1982 Port La Tour surveys 121
41. Length frequency (n=946), cumulative percent frequency, and percent meat yield (n=198) for each 5 mm size class of A. islandica from the 1981 Barrington Bay survey . . 123
42. Length frequency (n=2143), cumulative percent frequency, and percent meat yield (n=201) for each 5 mm size class of A. islandica from the 1982 Clarks Harbour survey . . 125

ABSTRACT

Chaisson, D.R. and T.W. Rowell. 1985. Distribution, abundance, population structure, and meat yield of the ocean quahaug (Arctica islandica) and Stimpson's surf clam (Spisula polynyma) on the Scotian Shelf and Georges Bank. Can. Ind. Rep. Fish. Aquat. Sci. 155: ix + 125 p.

As a continuation of the 1980 to 1982 assessment surveys for underutilized clam resources on the Scotian Shelf and Georges Bank, previously reported by Rowell and Chaisson (1983), a hydraulic dredge survey was conducted in 1983 to provide a first assessment of the resource on St. Anns Bank and to provide additional information on the Scotian Shelf and Georges Bank populations.

No significant catches of the principal target species, the ocean quahaug (Arctica islandica) and Stimpson's surf clam (Spisula polynyma), were located on St. Anns Bank. Because of the very rocky bottom conditions very few areas of this Bank could be dredged.

Ocean quahaugs were the only clam species found in significant concentrations on Georges Bank, although Stimpson's surf clams and Atlantic surf clams (Spisula solidissima) were encountered. Three high-density areas of ocean quahaugs, having a combined minimum biomass (live weight) of roughly 684,900 t and an estimated maximum sustainable yield (MSY) of between 3,404 t and 22,895 t,¹ were found.

Limited information on distribution and density of ocean quahaugs and Stimpson's surf clams are also provided for previously surveyed near-shore areas off southwest Nova Scotia.

Population structure and meat yield information are provided, where sufficient data are available, for additional areas surveyed in 1980 as well as for those areas for which abundance and distribution were previously reported (Rowell and Chaisson 1983). Correction factors which improve the biomass and MSY estimates provided by Rowell and Chaisson (1983) are also provided.

¹Range of MSY values were based on 90% confidence limits of the minimum biomass estimates.

RÉSUMÉ

Chaisson, D.R. and T.W. Rowell. 1985. Distribution, abundance, population structure, and meat yield of the ocean quahog (Arctica islandica) and Stimpson's surf clam (Spisula polynyma) on the Scotian Shelf and Georges Bank. Can. Ind. Rep. Fish. Aquat. Sci. 155: ix + 125 p.

Pour faire suite aux études d'évaluation relatives aux espèces de mollusques sous-exploitées du plateau continental Scotian et du banc Georges, qui se sont déroulées de 1980 à 1982 et sur lesquelles Rowell et Chaisson ont déjà fait rapport (1983), on a effectué, en 1983, une étude à la drague hydraulique afin d'obtenir une première évaluation des ressources du banc St. Anns et de recueillir d'autres renseignements sur les populations du plateau continental Scotian et du banc Georges.

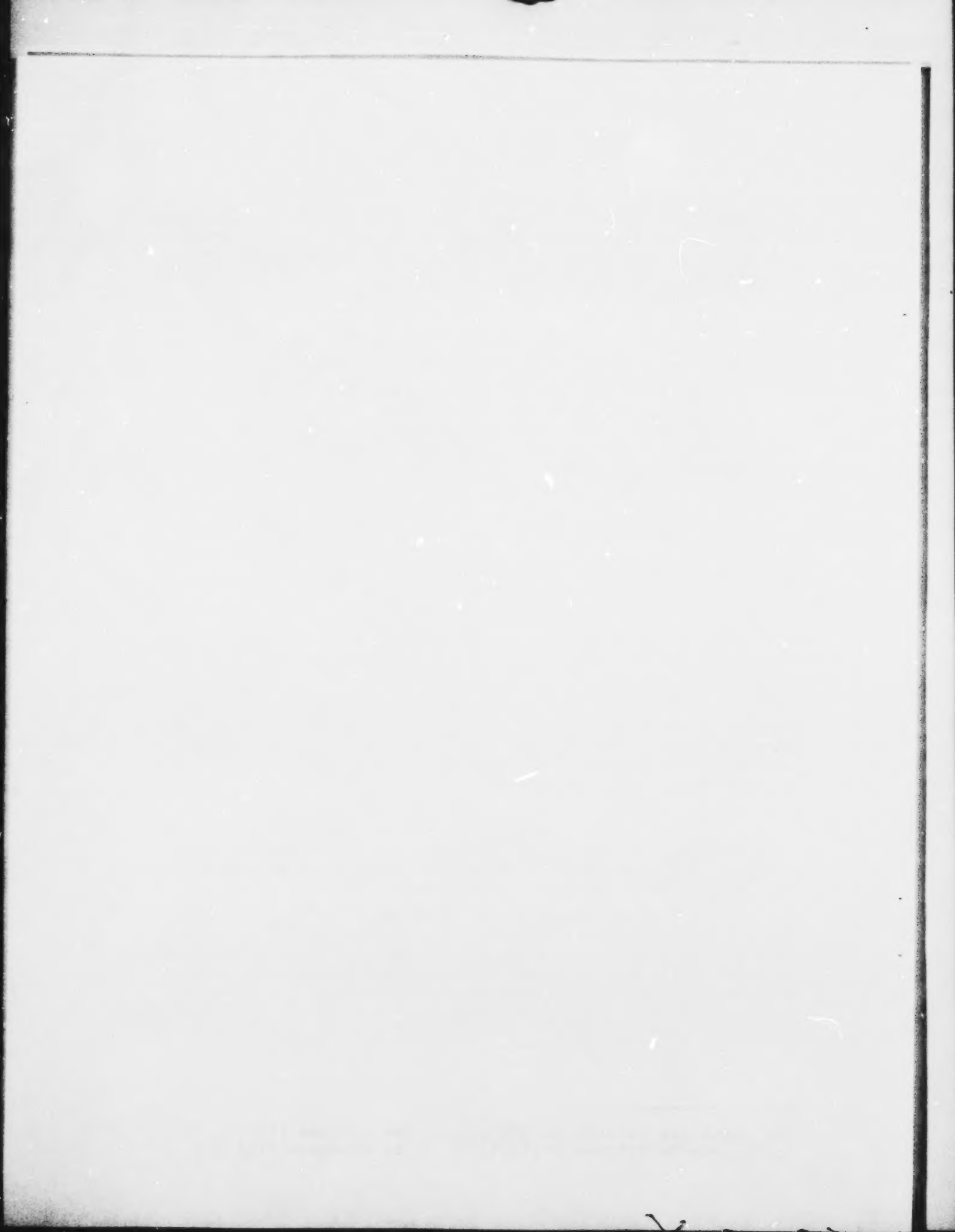
Sur le banc St. Anns, on n'a pas capturé un nombre important d'individus des principales espèces visées, à savoir le quahog nordique (Arctica islandica) et la mactre de Stimpson (Spisula polynyma). Étant donné que le fond du banc St. Anns est très rocheux, il n'a été possible d'en draguer que très peu de secteurs.

Bien que l'on ait capturé des mactres de Stimpson et des mactres d'Amérique (Spisula solidissima) sur le banc Georges, le quahog nordique est la seule espèce que l'on ait trouvée en concentrations importantes sur ce banc. On a en effet établi qu'il y a trois secteurs où la densité des quahogs nordiques est élevée; la biomasse minimale (poids vif) totale de cette espèce dans ces trois secteurs est d'environ 684,900 tonnes et on estime que le rendement maximal soutenable (RMS) se situe entre 3,404 tonnes et 22,895 tonnes.¹

Le rapport fournit également un nombre limité de renseignements sur la distribution et la densité des quahogs nordiques et des mactres de Stimpson dans ces secteurs se trouvant à proximité de la côte sud-ouest de la Nouvelle-Écosse qui ont déjà fait l'objet d'une étude.

Lorsqu'il y a suffisamment de données, la rapport donne des renseignements sur la structure des populations et le rendement en chair pour d'autres secteurs qui ont fait l'objet d'une étude en 1980, ainsi que pour les secteurs pour lesquels il existe déjà un rapport sur l'abondance et la distribution (Rowell et Chaisson, 1983). Le rapport indique également des facteurs de correction qui améliorent les prévisions relatives à la biomasse et au RMS établies par Rowell et Chaisson (1983).

¹La gamme des valeurs du RMS est fondée sur des limites de certitude de 90% des évaluations de la biomasse minimale.



INTRODUCTION

The ocean quahaug, Arctica islandica, and the Stimpson's surf clam, Spisula polynyma, both appear to have potential for commercial harvesting on some areas of the Scotian Shelf (Rowell and Chaisson 1983).

The ocean quahaug has become the second largest source of clam meat in the U.S. with landings of 35 million lb (15,873 t) of meat in 1983 (Mid-Atlantic Fishery Management Council, preliminary catch data²) with an approximate landed value of \$9.2 million U.S. Historically this species has supported one small fishery in the Port Medway area of Nova Scotia with reported landings of 907 t and 1,361 t for 1970 and 1971 respectively (Caddy et al. 1974) and, in recent years, another much smaller fishery in the Murray Harbour area of Prince Edward Island.

The Stimpson's surf clam (S. polynyma) has not yet been commercially exploited in eastern North America, but appears to have potential as a substitute species for the highly valued Atlantic surf clam Spisula solidissima. In the U.S. S. solidissima landings amounted to approximately 77% of the total 112 million lb (50,800 t) of clam meats landed in 1975 (Bakal et al. 1978). The fishery has since declined with 1983 landings estimated at 37.3 million lb (16,919 t) (Mid-Atlantic Fishery Management Council, preliminary catch data), with an approximate landed value of \$18.6 million U.S. (based on a current price of \$0.50 U.S./lb of meat). S. solidissima has a very limited distribution in Canadian waters, being most abundant just below the low water level in the warmer areas of the Gulf of St. Lawrence. It is clear from recent surveys (Rowell and Chaisson 1983) that no significant concentrations exist in offshore Canadian waters. S. polynyma, therefore, represents the greatest potential for development of an offshore surf clam fishery on the Scotian Shelf.

Rowell and Chaisson (1983) have described the distribution and abundance of both the ocean quahaug and the Stimpson's surf clam on the Scotian Shelf in Canadian Industry Report of Fisheries and Aquatic Sciences 142.

Due to a systematic error in the calculation of the mean catch weight at each station the estimated biomass, 90% confidence limits, and MSY's have been underestimated in Industry Report 142. To correct these values, they should be multiplied by 1.43 for A. islandica and 1.20 for S. polynyma.

²Mid-Atlantic Fishery Management Council, Room 2115, Federal Building, 300 South New Street, Dover, Del. 19901-6790, U.S.A.

with the exception of Middle Bank and Sable Island Bank Area 3 for A. islandica which should be multiplied by 1.76 and 2.24 respectively and Middle Bank for S. polynyma which should be multiplied by 1.90.

This supplementary report is directed at providing additional information of commercial interest such as meat yield and shell length data for these species in areas already described in Canadian Industry Report 142 (Rowell and Chaisson 1983) and to present new unreported survey information for Georges Bank, St. Anns Bank, and the near-shore area off southwestern Nova Scotia.

MATERIALS AND METHODS

MATERIALS

Inshore surveys were conducted along the southwestern shore of Nova Scotia in 1980, 1981, and 1982 (Rowell and Chaisson 1983). The 1980 survey was conducted using the 11.6 m "Gary and Rene II" while the 1981 and 1982 surveys were carried out on the 14.6 m MV "Sigma T" from the Bedford Institute of Oceanography, Dartmouth, Nova Scotia. Stations were sampled by hydraulic dredge in depths from 4-41 m.

Offshore surveys on the Scotian Shelf and Georges Bank were conducted in 1980, 1981, 1982, and 1983 using the research vessel "Delaware II" from the U.S. National Marine Fisheries Service.³ The vessel was fitted with a hydraulic dredge similar in size and configuration to a commercial clam dredge. The dredge, however, differed from commercial gear in that it utilized a dredge-mounted submersible pump (Crossen and Smolowitz 1980; Smolowitz and Nulck 1982). Tows were made between depths of 22-92 m.

Additional details on equipment and sampling regimes are described by Rowell and Chaisson (1983).

METHODS

Meat yields for both ocean quahaugs and surf clams were determined using data derived from condition indexes with a correction for fluid loss. These samples had been preserved frozen, then thawed and drained of mantle cavity fluid prior to processing. To determine meat yields, it is necessary to know

³United States Department of Commerce, National Marine Fisheries Service, Woods Hole, Ma. 02543. The use of this vessel and its specialized research dredge was made possible under a cooperative research agreement between Canada and the U.S. to investigate the biology and distribution of ocean quahaugs in northwest Atlantic waters.

the total weight of the clam, including fluid. In order to estimate the total clam weight it was therefore necessary to determine the percentage of fluid lost during the draining of the condition index samples. To do this, an additional 157 quahaugs with shell lengths between 54 and 99 mm were obtained from southwestern Nova Scotia. Individual quahaugs were weighed, both prior to and after draining, and then the shucked meats weighed. The percent meat yield was then determined, based on both drained and undrained total weights. A mean difference of 8.25% in meat yield was observed between determinations made using the drained and undrained samples. This percent difference was then used to convert the condition index (drained weight) meat yields to live weight (undrained) meat yields.

For surf clams no additional live animals were available for use in making the conversion. However, bushel weights (U.S.) of live clams for which length frequency data were also available had been recorded. From these data we were able to approximate the live weight for each 5 mm size class by the following method: Using the condition index data a mean total weight (drained) for each 5 mm size class was determined and multiplied by the total number of animals in each 5 mm size class of the length frequency data from the weighed bushel of live clams. The percentage of fluid was determined by taking the difference between the live (undrained) bushel weight and the bushel weight determined from the drained condition index samples (fluid weight = 16.71% of total weight). The condition index sample weights were then converted to live undrained weights and the percent meat yield determined for both the live undrained clams and the drained condition index clams. The difference in percent meat yield averaged 8.88%, and the percent meat yields determined from the condition index samples were therefore reduced by this amount.

RESULTS

PREVIOUSLY UNREPORTED SURVEYS

St. Anns Bank

St. Anns Bank was surveyed in 1983. A total of 52 stations (Fig. 1) were preselected, based on depth limitations of the gear, and on available information on the bottom topography and sediment types (MacLean and King 1971) to give maximum coverage of the Bank. However, due to the rocky bottom topography, as indicated by the depth sounder, only nine of the 52 stations could be fished. Ocean quahaugs were found at

three stations (Fig. 2) and Stimpson's surf clams at four (Fig. 3). Densities⁴ were less than 0.099 kg/m² for both species at all stations. Because of the very small numbers captured no meat yields or length frequencies are presented.

Georges Bank

A total of 98 stations were completed on Georges Bank during four surveys in 1980, 1981, 1982, and 1983 (Fig. 4). Three bivalve species with potential commercial value were found: the ocean quahaug (A. islandica), the Atlantic surf clam (S. solidissima), and the Stimpson's surf clam (S. polynyma).

Stimpson's surf clams were found at only two stations, and there in low densities (Fig. 5). No further data analysis was carried out.

Atlantic surf clams (S. solidissima) were found at 38 stations (Fig. 5), but only two stations had densities in excess of 0.200 kg/m². These clams ranged in length from 23-150 mm. Although present over much of Georges Bank, their low densities did not warrant further data analysis.

Ocean quahaugs were present at 51 (52%) of the stations sampled (Fig. 6). They ranged in length from 20-131 mm (Fig. 7) with a mean of 80.7 mm. When graded by commercial size classes the population consisted of 2.8% littlenecks, 25.4% cherrystones, and 72.0% chowders.⁵ Meat yields for each 5 mm size class ranged from 16.1-25.0% (Fig. 7) with an overall mean of 22.0%.

Quahaug densities reached a maximum of 9.4 animals/m² and 1.376 kg/m². Three high-density areas were identified (Fig. 6) with an estimated combined minimum biomass of 684,872 t (Table 1), and an MSY of between 5,136 t and 17,121 t calculated for a range of natural mortalities between 0.015 and 0.05 (Table 2). When 90% confidence intervals, based on Student's t-distribution, are applied to the biomass estimate, an MSY of between 3,404 t and 22,895 t is derived for the combined areas. Biomass and MSY estimates were not calculated for the remaining

⁴Densities for all areas are in kg/m² of total live weight.

⁵Size classes as defined by Bissel (1972):

Littleneck: 2-2.5 inch	Cherrystone: 2.5-3 inch	Chowder: >3 inch
50-63 mm	63-76 mm	>76 mm

area of Georges Bank as low densities would preclude any commercial fishing in this area.

Biomass estimates from which the MSY levels are calculated are assumed to be minimums since efficiency of the dredge is known to be less than 100%. Meyer et al. (1981) and Medcof and Caddy (1971) have made estimates suggesting that, under ideal conditions, hydraulic dredges may be between 91-95% efficient. In general, we may expect dredge efficiency to be well below these levels.

POPULATION STRUCTURE AND MEAT YIELD

Western and Sable Island Banks

Ocean quahaugs were present at 111 of the 130 stations (85%) sampled on Western and Sable Island Banks, and six areas were identified as having the greatest potential for commercial development (Fig. 8). To further define the population structure for each of these six areas length frequencies are given in Figures 9-14. Mean quahaug length for these areas ranged from 62.5-80.0 mm with a mean for all six areas of 70.1 mm (Table 3). Overall, the meat yields for the six areas ranged from 14.7-39.7% and the mean meat yields by area from 23.2-26.7%. The mean meat yield for all six areas combined was 24.8% (Table 3). The percentages of animals in each of three commercial size categories for each area are given in Table 3, with an overall average of 16.8% littlenecks, 34.6% cherrystones, and 35.0% chowders.

Stimpson's surf clams were present at 60 of 130 stations (46%) on Western and Sable Island Banks; however, densities did not exceed 0.099 kg/m^2 at any station (Fig. 15). They ranged in length from 36-145 mm (Fig. 16) with a mean of 102 mm. Mean meat yield for each 5 mm size class ranged from 23.6-42.9% (Fig. 16) with an overall mean of 37.4%.

Banquereau Bank

Stimpson's surf clams were present at 65 of 70 stations (93%) sampled on Banquereau Bank (Rowell and Chaisson 1983) with two high-density areas identified (Fig. 17). In Area 1 clams ranged in length from 24-149 mm (Fig. 18) with a mean of 101 mm. Mean meat yields for each 5 mm size class were between 35.8% and 47.6% with a mean of 42.6%. In Area 2 clams were between 60 mm and 139 mm in length (Fig. 19) with a mean of 112 mm. Mean meat yields for each 5 mm size class ranged from 40.9-47.1% with an overall mean of 44.7%.

Ocean quahaugs were present at 18 of 70 stations (26%) on Banquereau Bank. Densities were generally less than 0.099 kg/m^2 with only one station having a density in the $0.100\text{--}0.200 \text{ kg/m}^2$ range (Fig. 20). Quahaugs ranged in length from 46–110 mm with 4.3% littlenecks, 37.5% cherrystones, and 57.7% chowders. Mean meat yields for each 5 mm size class ranged from 19.4–28.9% (Fig. 21) with an overall mean of 27.2%.

Emerald Bank

Due to the rough bottom topography encountered, only five stations were completed on Emerald Bank (Fig. 22a). Ocean quahaugs were present at two stations with densities less than 0.099 kg/m^2 (Fig. 23a). Stimpson's surf clams (Fig. 23b) were not present at any of the five stations completed.

Middle Bank

Ocean quahaugs were present at 18 of 24 stations (75%) surveyed on Middle Bank (Fig. 22b). Densities were generally less than 0.099 kg/m^2 although two stations contained between 0.100 and 0.200 kg/m^2 (Fig. 24a). Quahaugs were between 36 mm and 115 mm (Fig. 25) in length with 4.7% littlenecks, 34.9% cherrystones, and 58.6% chowders. Mean meat yields for each 5 mm size class were between 18.4% and 36.2% with an overall mean of 24.5%.

Stimpson's surf clams were found at 11 (46%) stations on Middle Bank. Densities for the most part were low with only two stations having densities between 0.100 kg/m^2 and 0.200 kg/m^2 (Fig. 24b). Surf clams ranged in length from 33–140 mm (Fig. 26) with a mean of 97.1 mm. Mean meat yields for each 5 mm size class were between 39.7% and 52.0% with an overall mean of 44.7%.

Near-Shore Area

Eight stations (No. 170–177) were completed in the area between Roseway Bank and Shelburne, Nova Scotia (Fig. 27). Ocean quahaugs were present at densities of less than 0.099 kg/m^2 at five stations (Fig. 28). One station did have a high catch rate but its density, 0.137 kg/m^2 , was low due to the small overall size of the quahaugs (mean length 51 mm). Quahaugs in the near-shore area were small, in general ranging in length from 16–80 mm (Fig. 29) with 66.7% littlenecks, 1.3% cherrystones, and less than 1% chowders. Mean meat yields for each 5 mm size class were between 15.5% and 29.4% with an overall mean of 24.0%.

Stimpson's surf clams were present in low numbers (less than 0.099 kg/m^2) at three stations, and one high-density catch

of 0.306 kg/m^2 was recorded at Station 176 (Fig. 30). Surf clams ranged in length from 41-107 mm (Fig. 31) throughout the area, with a mean of 81 mm. Meat yields ranged from 33.4-46.4% with an overall mean of 38.2%.

Browns Bank

Ocean quahaugs were present at two of eight stations completed on Browns Bank (Fig. 28). Densities were very low with too few animals to warrant length frequency or meat yield analysis.

Stimpson's surf clams were present at three stations on Browns Bank with one station having a density of 0.263 kg/m^2 (Fig. 30). Surf clams ranged in length from 57-120 mm with a mean length of 95 mm. Meat yields were between 35.4% and 46.5% with an overall mean of 40.3% (Fig. 32).

Roseway Bank

Due to rough bottom topography, only seven stations were completed on the southwestern end of Roseway Bank (Fig. 27). Ocean quahaug densities did not exceed 0.099 kg/m^2 at any station (Fig. 28). Quahaugs were relatively small in size, between 37 mm and 82 mm, with 19.2% littlenecks, 60.2% cherry-stones, and 16.8% chowders (Fig. 33). Mean meat yields for each 5 mm size class were between 8.3% and 28.4%, with the overall mean of 11.6% being the lowest for any area surveyed.

Stimpson's surf clams were present at five stations on Roseway Bank. Densities were less than 0.099 kg/m^2 at four Stations and one high-density catch of 0.319 kg/m^2 was recorded at Station 165 (Fig. 30). Surf clams ranged in length from 37-93 mm (Fig. 34) with a mean of 82.4 mm. Mean meat yield ranged from 24.3% to 40.6% with an overall mean of 35.5%.

Inshore Areas

As reported in Rowell and Chaisson (1983), ocean quahaugs were the only subtidal bivalves of commercial importance encountered in significant numbers in the inshore areas surveyed. Seven areas were identified as having the most potential for commercial development (Fig. 35). Quahaugs from these areas ranged in length from 16-113 mm (Fig. 36-42) with an overall mean of 75 mm (Table 4). The percentages of quahaugs in each of three commercial size classes for each of the seven areas and for the combined area are given in Table 4. For all areas combined there were 11.7% littlenecks, 26.9% cherrystones,

and 56.1% chowders. Mean meat yields for each 5 mm size class are given, by area, in Figures 36-42; and the overall means for these areas are given in Table 4. Mean meat yields ranged from 21.3-25.7% for the seven areas with an overall mean of 23.0%.

Due to the rocky bottom topography, as indicated by the depth sounder, no stations were completed on Baccaro or LaHave Banks. The areas traversed on Baccaro and LaHave Banks are indicated by the vessel cruise track (Fig. 27).

For convenience in locating potential fishing areas, all station locations are provided in Table 5.

DISCUSSION

RESOURCE

St. Anns Bank

The results of the St. Anns Bank survey were disappointing. Prior to the survey, it was felt that the Bank's proximity to shore would be advantageous in that daily trips, with short steaming times, would be possible. Available information on bottom sediments suggested conditions would be similar to those in other areas surveyed with the hydraulic dredge. However, sediment classifications used in the surficial geological charts (MacLean and King 1971) cover a wide size range and, for this Bank, the sediment grain size proved to be at the high end of the scale. The bottom area suitable for towing a hydraulic dredge was very limited and, in areas where tows were made, concentrations of quahaugs and surf clams were very low.

Georges Bank

Georges Bank appears to lie within the transitional zone in the distribution of S. solidissima and S. polynyma (Abbott 1974; Gosner 1971). To the northeast on the Scotian Shelf, only seven stations near Sable Island contained any S. solidissima. No S. solidissima were collected from the inshore areas surveyed (minimum depth surveyed=4 m). S. polynyma is uncommon from Georges Bank south, although it has been reported in Massachusetts Bay ("Delaware II" Cruise Report 71-16). It is of no importance to the U.S. Atlantic surf clam fishery.

Of the three species considered, only ocean quahaugs were present in significant numbers on Georges Bank. The mean density for the three high catch areas identified was 0.475 kg/m² (Table 1), a level significantly higher than the mean density of

⁶Available from: United States Department of Commerce,
National Marine Fisheries Service, Woods Hole, Ma. 02543,
U.S.A.

0.260 kg/m² for the six high-density areas on Western and Sable Island Banks (Rowell and Chaisson 1983). Area 1 recorded the highest mean density of any offshore area surveyed at 0.841 kg/m² (Table 1).

Estimates of MSY were derived for various rates of natural mortality between 0.015 and 0.03 using the formula $C_{max} = XMB_0$ (Gulland 1971) for Areas 1, 2, and 3 separately and combined (Table 2). Growth studies (Jones 1980; Murawski et al. 1980; Thompson et al. 1980) have shown quahaugs to be slow growing and extremely long lived, living well in excess of 100 yr. Ropes and Pyoas (1982) developed a growth curve for Georges Bank quahaugs [shell length (mm) = $42.4005(\text{age})^{0.1981}$] using internal shell banding to determine age in years (Ropes 1982a). From the above equation and length frequency data from Georges Bank, 1.2% of the population was determined to live to 100 yr, giving a natural mortality rate (M) of 0.044. This compares to 1.3% (M=0.043) for quahaugs from inshore areas of Nova Scotia (Rowell and Chaisson 1983).

Based on a mortality rate of $M = 0.044$, and a combined biomass of 684,872 t for Areas 1, 2, and 3, an MSY of 15,067 t $\pm 5,081$ t is derived when 90% confidence limits are applied. With a 22% meat yield this suggests 3.3 million kg (7.3 million lb) ± 1.1 million kg (2.4 million lb) of meat could be harvested annually.

Population Structure and Meat Yield

Murawski and Serchuk (1979) reported mean quahaug lengths for Mid-Atlantic Bight areas of between 80.7 mm and 95.7 mm as compared with 66.0-86.6 mm and 51.0-80.0 mm respectively for the inshore and offshore areas of the Scotian Shelf. The mean length for Georges Bank ocean quahaugs (80.7 mm) was the same as the lower end of the range for the Mid-Atlantic Bight areas. The combined high-density areas of Western and Sable Island Banks have in excess of 51% of quahaugs in the cherrystone and littleneck sizes (less than 76 mm).

Mean quahaug meat yields ranged from a low of 11.6% on Roseway Bank to a high of 27.2% on Banquereau Bank. Overall, meat yield averaged 23%. In U.S. areas, meat yields are reported to range from 13-27% with a mean of 20.7% (Bakal et al. 1978). Since data for most of the areas surveyed show a general decrease in meat yield with increasing shell length, the smaller mean size of quahaugs from Canadian waters may explain the slightly higher mean meat yield observed.

Mean length of Stimpson's surf clams ranged from 81 mm in the near-shore area to 112 mm on Banquereau Bank, compared with 108-124 mm for the same species along the Alaskan Peninsula (Hughes and Bourne 1981). Stimpson's surf clams attain a maximum length of 150 mm (Ropes 1982b) compared to a recorded maximum of 226 mm for S. solidissima (Ropes and Ward 1977).

Meat yields for Stimpson's surf clams were relatively stable between areas with a range of 35.5-44.7%, with the two high-density areas of Banquereau Bank giving yields of 42.6% and 44.7%. This compares to a 37% meat yield for Stimpson's surf clams in Alaskan waters (Hughes and Bourne 1981) and 30% for U.S. surf clams, S. solidissima (Bakal et al. 1978).

INDUSTRY OVERVIEW

Catch Rates

Although the average clam density reported for the offshore areas surveyed north of Georges Bank is less than those reported for inshore areas, the species are present over large areas (Rowell and Chaisson 1983) and a sufficient number of stations indicated densities at or above the 0.34 kg/m² used as a guideline for commercial viability in Rowell and Chaisson (1983). Because of the large area covered and the distance between sampling points (5-10 nautical miles), these individual high-density catches could be indicative of relatively large concentrations. Differences, however, in the catch rates between commercial and scientific vessels make it difficult to utilize the survey data in assessing potential commercial viability. Tows made with hydraulic dredges on research cruises are standardized in that the same procedures and fishing times are used. This standardization allows the direct comparison of catch rates between areas and years. Commercial vessels may vary both tow and operational procedures, depending on general knowledge of the area (i.e. depth, sediment type, bottom hardness, density of clams, etc.) to optimize catch rates. As a result, commercial vessels will generally produce higher catch rates than research vessels, even though the equipment fished is similar.

No comparison has been made between catch rates of the equipment and vessel used in this survey and those obtained by commercial vessels. In one comparison carried out in U.S. waters, commercial catch rates (clams per tow) were found to be two to 12 times greater than research vessel catch rates (Cruise Results, "Delaware II," 1977⁷). The dredge used by the "Delaware II" in this latter comparison was, however, very different from the submersible pump/dredge system used in the current survey; and the differences in catch rates are not

⁷Available from: United States Department of Commerce, National Marine Fisheries Service, Woods Hole, Ma. 02543, U.S.A.

necessarily indicative of those which would be obtained with the present dredge system. It is felt that the "Delaware II" catch rates, using the present system, would be more similar to commercial catch rates than those of the earlier system (A. Thoms, pers. comm.⁸).

U.S. Clam Industry

The major finished products of the U.S. clam industry are grouped in four classes: canned clam chowder, whole and minced clams, breaded clams, and canned sauces and juices. Since early in the development of the fishery, the bulk of these products have been derived primarily from Atlantic surf clams. In the period 1971-76, ocean quahaugs accounted for only 1% of the value of all finished clam products. The value of finished quahaug products grew rapidly to 12% in 1977 and 15% in 1979 (Mid-Atlantic Fishery Management Council, 1981). This growing trend in the importance of the quahaug resource to the fishery can also be seen in the increased number of plants processing quahaugs. In 1971, 91% of plants processed only surf clams. By 1979, 32% of plants processed both surf clams and quahaugs.

Current U.S. fishing capacity is approximately 270 million lb of meat per year with quotas of approximately 70 million lb for quahaugs and surf clams combined (Mid-Atlantic Fishery Management Council, 1981). Current management plans, developed by the Mid-Atlantic Fishery Council, suggest yields of roughly 30-50 million lb of meat for surf clams and 40-60 million lb of meat for ocean quahaugs could be harvested without exceeding MSY levels. Harvesting at these levels could amount to an increase in U.S. landings of as much as 36% above current quota levels. This capacity for expansion within the U.S. fisheries for these species must be taken into account when considering development of the Canadian fishery. Additionally, the U.S. fishery appears to be demand limited; and prices are likely to be sensitive to any dramatic increases in supply.

The average 1983 landed price for ocean quahaug meat was \$0.31 U.S./lb⁹ (T. Hoff, pers. comm.¹⁰) or \$3.10/bushel (10 lb of meat per U.S. bushel of shellstock).

⁸A. Thoms, technician, United States Department of Commerce, National Marine Fisheries Service, Woods Hole, Ma. 02543, U.S.A.

⁹Prices per pound and bushel, and estimated Canadian fishery values are in U.S. dollars.

¹⁰T. Hoff, biologist, Mid-Atlantic Fishery Management Council, Room 2115, Federal Building, 300 South New Street, Dover, Del. 19901-6790, U.S.A.

The U.S. surf clam industry can utilize clams of any size in the production of chowders and related products, but the highest valued surf clams are those utilized in the strip clam market which require a minimum size of 5.5 inches (139 mm). (B. Nichols pers. comm.¹¹).

The approximate current landed value for U.S. surf clams (*S. solidissima*) is \$0.50/lb (\$1.10/kg) (T. Hoff, pers. comm.) of meat or \$8.50/U.S. bushel based on an average meat yield of 17 lb (7.7 kg) per bushel.

Potential for a Canadian Fishery

The calculated MSY for ocean quahaugs in Canadian waters varies depending on the mortality rate assumed, and ultimately will also be dependent on the number of areas which prove capable of supporting a commercial harvest. If only the seven inshore areas and the six high-density areas of Western and Sable Island Banks are considered, and a mortality rate of 0.043 is assumed, an annual MSY harvest of 14,527 t¹² could be possible. With a 23% meat yield this translates to 7.4 million lb (3,300 t) of meat with a value on the order of \$2.2 million U.S. A Canadian fishery of this size would, relative to the 1983 U.S. harvest of 35 million lb, increase total landings of quahaug meat for the U.S. market by 21%. U.S. landings of ocean quahaugs have remained relatively stable in recent years, fluctuating between 33 and 36 million lb of meat between 1980 and 1983. Although a 21% increase in quahaug meat on the U.S. market would exceed current levels of increase (e.g. 7% from 1980-81), a gradual influx of Canadian quahaugs may not adversely effect market prices since historically this market has absorbed considerably larger increases.

Based on a mean bushel weight of 29 kg (63 lb), a slightly higher average meat yield, and an approximate price of \$0.66/kg (\$0.32/lb) of meat, the landed value for Scotian Shelf quahaugs would be roughly \$4.50 U.S. per U.S. bushel.¹³

¹¹B. Nichols, biologist, Management Division, United States Department of Commerce, National Marine Fisheries Service, Gloucester, Ma. 01930, U.S.A.

¹²Estimated MSY based on the combined biomass derived from Tables 1 and 2 of Industry Report 142 for those areas considered when corrected by a factor of 1.43.

¹³Canadian (Imperial) bushel = 1.032 U.S. bushels.

The smaller average size of Scotian Shelf quahaugs may also prove advantageous for entering markets generally restricted to the bay quahaug (*Mercenaria mercenaria*). There are reports that a small fishery to supply ocean quahaugs for the half shell trade has developed off the coast of Maine with prices in the area of \$30 U.S. per U.S. bushel for ocean quahaugs in the 1.5-2.0 inch size range. With the limited U.S. supply of bay quahaugs, and current high demand, this market could possibly be exploited by Maritime fishermen.

The market demand and price for Stimpson's surf clams cannot be directly compared with those for the traditionally harvested surf clam; however, it is likely that demand and price will be similar, since meat quality and other characteristics are quite similar (Hughes et al. 1977). With this assumption, a bushel weighing 58.4 lb (26.4 kg) and an approximate average meat yield of 43% would give 25.1 lb (11.3 kg) of meat for a value of roughly \$12.55 per U.S. bushel. Using the more conservative meat yield of 37% found by Hughes and Bourne (1981) for Alaskan Stimpson's surf clams, a bushel would give 21.6 lb (9.8 kg) for a value of \$10.80 per bushel. However, as noted above, the high-value strip clam market generally requires clams of at least 139 mm shell length. With less than 1% of the Stimpson's surf clams from Banquereau Bank being greater than 139 mm in length, a Canadian fishery for this species would be virtually excluded from this high-return area of the market.

With an MSY of 67,906 t¹⁴ (Rowell and Chaisson 1983) and a 37-43% meat yield for Areas 1 and 2 on Banquereau Bank, the potential landed value would likely be between \$28-32 million U.S. The potential harvest of 55-64 million lb (25-29 million kg) of meat annually in Canadian waters could surpass current U.S. surf clam landings. It should be noted that the MSY estimates are in part based on growth data for *S. polynyma* from Alaskan waters. If the mortality rates developed here are significantly lower (longer lived and slower growing) then the annual MSY would be substantially reduced.

CONCLUSIONS

The survey has determined the availability and mapped the distribution of substantial clam resources on the Scotian Shelf and Georges Bank. Ocean quahaugs were located principally in the inshore areas and on Western and Sable Island Banks and Georges Bank. Stimpson's surf clams were found principally on Banquereau Bank. The survey has also provided a baseline estimate of minimum abundance for both species against which the effect of any future fishery can be assessed.

¹⁴Estimated MSY at the 0.25 mortality rate in Table 4 of Canadian Industry Report of Fisheries and Aquatic Sciences 142.

ACKNOWLEDGEMENTS

The authors wish to thank T. Amaratunga of the Invertebrates and Marine Plants Division for his input to the planning and early development of the project, A. Thoms of the National Marine Fisheries Service and C.M. Hawkins of the Invertebrates and Marine Plants Division for their assistance in conducting the 1983 offshore survey, and F. Budden of the Invertebrates and Marine Plants Division for her assistance in the data analysis.

REFERENCES

- Abbott, R.T. 1974. American Seashells, 2nd Edition. Van Nostrand Reinhold Co., N.Y.: 663 p.
- Bakal A., W.F. Rathjen, and J. Mendelsohn. 1978. Ocean quahaug takes supply spotlight as surf clam dwindles. Food Product Development 12(1): 70-78.
- Bissell, G.E. 1972. Review of the east coast quahaug fishery (guidelines for development). Western Consultants, P.O. Box 245, West Vancouver, B.C.: 93 p.
- Caddy, J.F., R.A. Chandler, and D.G. Wilder. 1974. Biology and commercial potential of several underexploited molluscs and crustaceans on the Atlantic coast of Canada. A paper presented to the Federal-Provincial Fisheries Committee meeting on Utilization of Atlantic Resources, Montreal, P.Q., Feb. 5-7, 1974: 30 p.
- Crossen, J.M. and R.J. Smolowitz. 1980. Power system requirements of an electro-hydraulic clam dredge. Mar. Tech. Proc. 16th Ann. Conf. Mar. Tech. Soc.: 433-438.
- Gosner, K.L. 1971. Guide to identification of marine and estuarine invertebrates. Cape Hatteras to the Bay of Fundy. Interscience, John Wiley and Sons, Toronto, Ont.: 693 p.
- Gulland, J.A. 1971. The fish resources of the ocean. Fishery News (Books) Ltd., Surrey, England: 255 p.
- Hughes, S.E., R.W. Nelson, and R. Nelson. 1977. Initial assessments of the distribution, abundance, and quality of subtidal clams in the S.E. Bering Sea. Co-op. Indust. Fed. State of Alaska Study, U.S. Dept. Comm., Nat. Mar. Fish. Service, Seattle Lab.: 58 p.
- Hughes, S.E. and N. Bourne. 1981. Stock assessment and life history of a newly discovered Alaskan surf clam (Spisula polynyma) resource in the southeast Bering Sea. Can. J. Fish. Aquat. Sci. 38(10): 1173-1181.

- Jones, D.S. 1980. Annual cycle of shell growth increment formation in two continental shelf bivalves and its paleoecological significance. *Paleobiology* 6: 331-340.
- MacLean, B. and L.H. King. 1971. Surficial geology of Banquereau and Misaine Bank map area. *Mar. Sci. Paper* 3 (also *Geo. Surv. Can. Pap.* 71-52): 19 p.
- Medcof, J.C. and J.F. Caddy. 1971. Underwater observations on the performance of clam dredges of three types. Paper prepared for Gear and Behaviour Committee, Int. Council. *Explor. Sea, C.M.*1971/B:10: 5 p.
- Meyer, T.L., R.A. Cooper, and K.J. Pecci. 1981. The performance and environmental effects of a hydraulic clam dredge. *Mar. Fish. Rev.* 43(9): 14-22.
- Mid-Atlantic Fishery Management Council. 1981. Amendment No. 3 to the fishery management plan for the surf clam and ocean quahaug fisheries and a supplemental environment impact statement. Mid-Atlantic Fishery Management Council, Dover, De.: 65 p.
- Murawski, S.A. and F.M. Serchuk. 1979. Shell length-meat weight relationships of ocean quahaugs, Arctica islandica, from the Middle Atlantic Shelf. *Proc. Nat. Shell. Assoc.* 69: 40-46.
- Murawski, S.A., J.W. Ropes, and F.M. Serchuk. 1980. Growth studies of the ocean quahaug, Arctica islandica. *Int. Council. Explor. Sea, C.M.*1980/K:38: 24 p.
- Ropes, J.W. and G.E. Ward Jr. 1977. The Atlantic coast surf clam fishery. 1974. *Mar. Fish. Rev.* 34(5): 18-23.
- Ropes, J.W. 1982a. Procedures for preparing acetate peels of embedded valves of Arctica islandica for ageing. U.S. Dept. Comm., Nat. Mar. Fish. Serv., Woods Hole Lab. Ref. No. 82-18: 8 p.
- 1982b. The Atlantic coast surf clam fishery, 1965-1974. *Mar. Fish. Rev.* 44(8): 1-14.
- Ropes, J.W. and D. Pyoas. 1982. Preliminary age and growth observations of ocean quahaugs, Arctica islandica Linne, from Georges Bank. *Int. Council. Explor. Sea, C.M.*1982/K: 15, 6 p.
- Rowell, T.W. and D.R. Chaisson. 1983. Distribution and abundance of the ocean quahaug (Arctica islandica) and Stimpson's surf clam (Spisula polynyma) resource on the Scotian Shelf. *Can. Ind. Rep. Fish. Aquat. Sci.* 142: v+75p.

- Smolowitz, R.J. and V.E. Nulk. 1982. The design of an electrohydraulic dredge for clam surveys. Mar. Fish. Rev. 44(4): 1-18.
- Thompson, I., D.S. Jones, and D. Dreibelbis. 1980. Annual internal growth banding and life history of the ocean quahaug Arctica islandica (Mollusca:Bivalvia). Mar. Biol. 57: 25-34.

Table 1. Density and biomass of ocean quahaugs in High-Density Areas 1, 2, and 3 of Georges Bank.

Bank	Area	Km ²	$\bar{X}$ Density (kg/m ²)	Biomass (t) *	+ 90% C.I. (t)
Georges	1	1,163	0.443	515,209	220,332
	2	144	0.841	121,104	266,400
	3	144	0.289	41,616	33,641
Combined		1,451	0.472	684,872	230,962

*Total weight of meat may be estimated from the biomass by using an average meat yield of 22.0% for Georges Bank.

Table 2. Estimates of maximum sustainable yield (MSY) in metric tons for Arctica islandica at various rates of natural mortality (M) as derived from Gulland's 1971 Model $C_{max} = XMB_0$ where M = the instantaneous rate of natural mortality; B_0 is the virgin stock size; and, X the proportion of B_0 which may be harvested annually is 0.5.

Bank	Area	Km ²	Biomass (t)	MSY (t)					
				Mortality (M)					
				0.015	0.020	0.025	0.035	0.044	0.050
Georges	1	1,163	519,861	3,898	5,189	6,498	9,097	11,436	12,996
	2	144	121,104	908	1,211	1,513	2,119	2,664	3,027
	3	144	41,616	312	416	520	728	915	1,040
Combined		1,451	684,872	5,136	6,848	8,560	11,985	15,067	17,121

*Total weight of meat may be estimated from the MSY by using an average meat yield of 22.0% for Georges Bank.



Table 3. Mean length, mean meat yield, and the percentage of animals in each of three commercial size classes for ocean quahaugs from areas on Western and Sable Island Banks.

Area	$\bar{X}$ Length (mm)	$\bar{X}$ Meat Yield (%)	% Littlenecks*	% Cherrystone*	% Chowder*
1	64.7	23.2	63.1	20.8	13.9
2	80.0	23.3	11.2	31.1	54.5
3	76.4	25.1	12.0	32.7	53.2
4	69.4	26.0	14.2	53.7	22.0
5	68.0	24.7	8.8	42.9	23.5
6	62.5	26.7	4.0	27.0	43.4
Combined	70.1	24.8	16.8	34.6	35.0

*Size classes as defined by Bissel (1976). Littleneck 2"-2.5" (50-63 mm), Cherrystone 2.5"-3" (63-76 mm), Chowder 3" (>76 mm). Between 2-30% of quahaugs were <2".

Table 4. Mean length, mean meat yield, and the percentage of animals in each of three commercial size classes for ocean quahaugs from seven inshore areas.

Area	$\bar{X}$ Length (mm)	$\bar{X}$ Meat Yield (%)	% Littlenecks* & Cherrystones*	% Chowder*
LaHave	72.6	24.8	22.0	21.6
Jordan Bay	79.4	21.3	8.1	21.5
Shelburne 1	78.4	25.7	3.2	38.8
Negro Harbour	86.6	21.9	0.6	11.2
Port Latour	64.2	23.7	43.9	21.1
Barrington Bay	78.1	22.8	1.3	35.3
Clark's Harbour	66.0	21.5	3.2	38.8
Inshore Areas				
Combined	75.0	23.0	11.7	26.9
				56.1

*Size classes as defined by Bissel (1976). Littleneck 2"-2.5" (50-63 mm), Cherrystone 2.5"-3" (63-76 mm), Chowder 3" (>76 mm). Between 0-15% were <2".

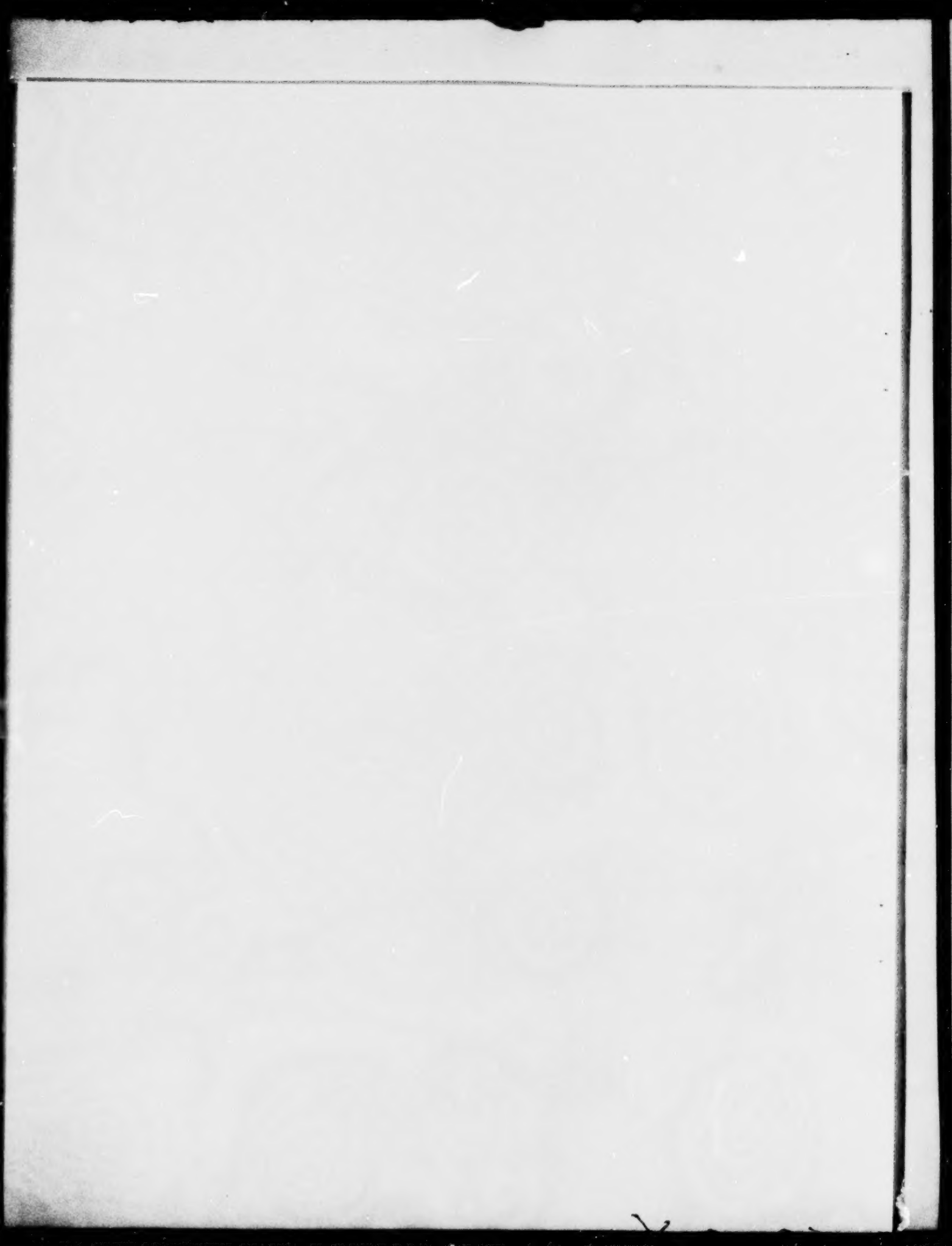


Table 5. Station locations, 1980-1983.

Bank	Year	Station	Lat.	Long.	Loran X	Loran Y	Depth (m)
Emerald Bank	1981	328	47°13'	67°13'			58
		329	43°37'	62°29'	13509.2	29600.1	75
		330	43°32'	62°29'	13482.3	29600.1	81
		331	43°29'	62°24'	13470.8	29560.2	80
		332	43°28'	52°21'	13464.9	29533.2	79
		333	43°26'	62°19'	13455.0	29515.6	79
Western Bank	1981	334	43°29'	61°49'	13499.0	29299.5	82
		335	43°25'	61°42'	13482.1	29247.1	78
		336	43°36'	61°42'	13543.6	29250.3	76
		337	43°39'	61°48'	13562.7	29301.6	76
		338	43°45'	61°40'	13500.3	29249.7	67
		339	43°55'	61°39'	13658.6	29249.3	74
		340	43°58'	61°32'	13679.5	29197.5	74
		341	43°57'	61°27'	13675.2	29150.5	68
		342	43°49'	61°34'	13622.6	29201.1	57
		343	43°47'	61°27'	13616.7	29145.0	51
		344	43°38'	61°34'	13566.7	29200.7	63
		345	43°37'	61°28'	13561.8	29148.3	53
		346	43°29'	61°36'	13509.4	29200.5	73
		347	43°27'	61°29'	13504.0	29153.2	76
		348	43°19'	61°36'	13545.5	29197.7	80
		349	43°21'	61°26'	13473.6	29100.1	79
		350	43°23'	61°16'	13490.1	29049.9	77
		351	43°31'	61°22'	13531.1	29101.5	74
		352	53°33'	51°15'	13545.2	29048.5	67
		353	43°41'	61°21'	13587.1	29101.1	49
		354	43°43'	61°15'	13600.6	29051.4	47
		355	43°50'	61°20'	13642.9	29098.3	53
		356	43°52'	61°14'	13652.6	29051.6	54
Sable Island	1981	357	44°00'	61°20'	13695.6	29101.6	92
		358	44°02'	61°13'	13709.0	29050.0	69
		359	44°13'	61°11'	13768.3	29033.2	76
		360	44°14'	61°07'	13777.4	28997.2	65
		361	44°16'	61°00'	13787.3	28947.6	72
		362	44°06'	61°01'	13731.7	28950.5	54
		363	44°04'	61°06'	13723.9	29000.1	60
		364	43°56'	61°00'	13681.6	28951.7	55
		365	43°54'	61°07'	13667.0	29098.8	55
		366	43°48'	61°00'	13637.3	28949.6	48
		367	43°44'	61°08'	13613.4	29002.7	54
		368	43°35'	61°00'	13572.6	28949.8	66
		369	43°34'	61°07'	13558.4	29000.1	67
		370	43°24'	61°07'	17505.4	28999.1	75

...Cont'd.

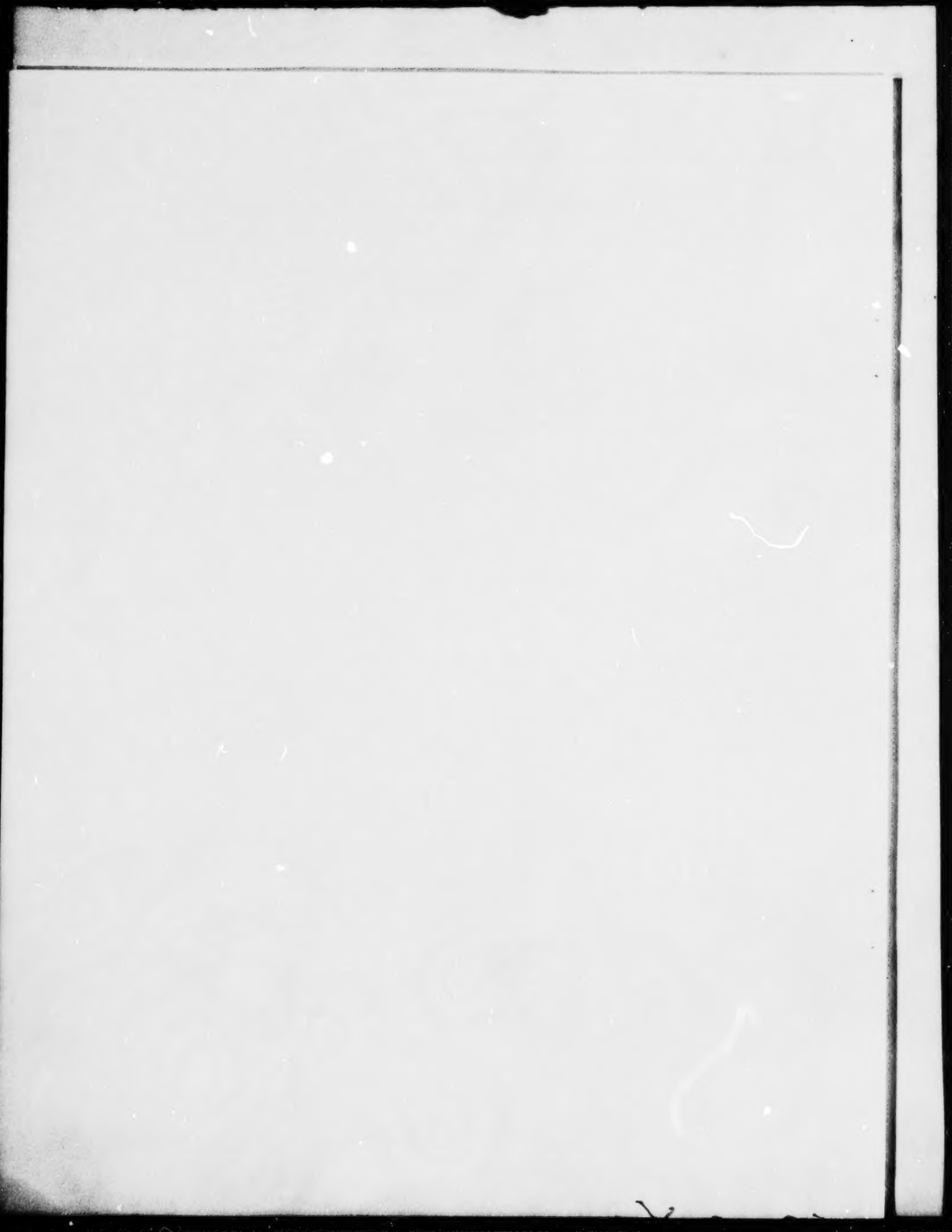


Table 5. Cont'd.

Bank	Year	Station	Lat.	Long.	Loran X	Loran Y	Depth (m)
Sable Island	1981	371	43°26'	61°00'	13520.3	28948.2	72
		372	43°27'	60°54'	13534.1	28899.8	71
		373	43°33'	60°48'	13569.2	28849.9	68
		374	43°37'	60°55'	13586.5	28899.7	61
		375	43°43'	60°48'	13622.1	28852.8	47
		376	43°47'	60°54'	13638.8	28899.8	42
		377	43°53'	60°47'	13675.1	28855.4	37
		378	43°57'	60°54'	13690.0	28899.5	43
		379	44°07'	60°52'	13745.9	28897.1	38
		380	44°13'	60°46'	13777.3	28848.2	70
		381	44°04'	60°46'	13728.3	28850.7	28
		382	43°52'	60°39'	13669.1	28797.9	33
		383	43°51'	60°35'	13669.7	28748.9	38
		384	43°42'	60°41'	13618.3	28798.43	54
		385	43°42'	60°35'	13619.2	29197.5	74
		386	43°32'	60°42'	13567.6	28798.5	71
		387	43°32'	60°35'	13570.0	28747.7	72
		388	43°36'	60°26'	13596.7	28697.8	67
		389	43°39'	60°20'	13613.6	28650.8	63
		390	43°45'	60°26'	13646.0	28698.4	55
		391	43°50'	60°19'	13672.9	28642.9	44
		392	43°46'	60°14'	13652.1	28608.6	60
		393	43°39'	60°13'	13617.6	28599.7	64
		394	43°48'	60°09'	13670.1	28550.0	49
		395	43°44'	60°06'	13645.5	28514.9	56
		396	43°40'	60°00'	13631.0	28499.2	73
		397	43°42'	59°53'	13640.6	28449.0	74
		398	43°50'	60°01'	13677.3	28504.0	43
		399	43°49'	59°53'	13668.0	28451.0	54
		400	43°52'	59°47'	13693.1	28403.8	38
		401	43°42'	59°45'	13647.5	28402.0	79
		402	43°49'	59°40'	13683.0	28349.3	49
		403	43°47'	59°33'	13679.8	28299.8	61
		404	43°47'	59°27'	13679.8	28249.5	71
		405	43°57'	59°34'	13722.1	28246.7	40
		406	43°51'	59°20'	13700.3	28198.4	63
		407	43°51'	59°14'	13702.7	28149.6	76
		408	43°57'	59°14'	13729.8	28150.0	42
		409	43°59'	59°08'	13740.6	28100.7	49
		410	44°02'	59°15'	13752.1	28149.1	31
		411	44°07'	59°29'	13770.6	28253.5	62
		412	44°05'	59°41'	13759.0	28351.8	61
		413	44°02'	59°47'	13740.2	28400.1	51
		414	44°06'	59°54'	13759.6	28448.5	73
		415	44°02'	60°00'	13738.3	28499.7	51
		416	44°07'	60°07'	13758.8	28551.2	68
		417	44°03'	60°14'	13739.8	28599.8	51

...Cont'd.

Table 5. Cont'd.

Bank	Year	Station	Lat.	Long.	Loran X	Loran Y	Depth (m)
Sable Island	1981	418	44°06'	60°20'	13752.0	28650.8	71
		419	44°05'	60°27'	13740.2	18701.9	49
		420	44°08'	60°33'	13758.3	28751.5	69
		421	44°06'	60°39'	13745.3	28800.5	51
Sable Island	1982	325	44°12'	60°53'	13767.2	18898.0	31
		326	44°08'	60°46'	13749.5	28845.1	22
		327	44°11'	60°41'	13766.8	28805.7	76
		328	44°05'	60°35'	13738.9	28764.9	45
		329	44°03'	60°22'	13735.6	28657.3	45
		330	44°08'	60°14'	13760.9	28602.2	76
		331	44°03'	60°18'	13739.0	28554.2	48
		332	44°06'	60°02'	13757.8	28504.4	65
		333	44°01'	59°54'	13733.7	28447.4	36
		334	44°08'	59°54'	13733.7	28447.4	36
		335	44°08'	59°34'	13775.6	28293.0	73
		336	44°05'	59°19'	13776.7	28178.6	41
		337	43°59'	59°22'	13736.0	28206.6	35
		338	43°55'	59°21'	13720.0	28200.7	47
		339	43°55'	59°09'	13720.2	28109.2	72
		340	43°48'	59°20'	13689.3	28196.6	71
		341	43°52'	59°28'	13700.3	28253.5	48
		342	43°55'	59°34'	13715.7	28294.0	31
		343	43°54'	59°40'	13707.3	28346.7	30
		344	43°52'	59°36'	13698.0	28313.6	59
		345	43°44'	59°39'	13662.3	28338.8	69
		346	43°48'	59°47'	13673.2	28397.7	47
		347	43°51'	59°55'	13686.2	28459.0	41
		348	43°45'	60°00'	13654.3	28509.2	54
		349	43°38'	60°07'	13614.4	28554.1	75
		350	43°35'	60°18'	13595.9	28626.7	75
		351	43°42'	60°13'	13635.7	29599.4	55
		352	43°51'	60°09'	13681.3	28563.3	35
		353	43°52'	60°15'	13679.5	28614.5	32
		354	43°50'	60°27'	13668.0	28700.6	37
		355	43°42'	60°24'	13626.8	28678.2	57
		356	43°32'	60°27'	13574.1	28701.9	79
		357	43°37'	60°33'	13596.4	28749.7	62
		358	43°46'	60°35'	13642.9	28763.4	51
		359	43°47'	60°43'	13641.9	28825.1	33
		360	43°38'	60°41'	13594.1	28805.3	63
		361	43°39'	60°47'	13548.6	28849.6	72
		362	43°38'	60°47'	13590.8	28849.7	53
		363	43°50'	60°52'	13655.4	28888.7	39
		364	43°56'	60°42'	13689.8	28816.8	31
		365	44°01'	60°44'	13714.2	28835.3	24
		366	44°01'	60°56'	13711.1	28925.5	45

...Cont'd.

Table 5. Cont'd.

Bank	Year	Station	Lat.	Long.	Loran X	Loran Y	Depth (m)
Middle	1981	422	44°23'	60°41'	13829.5	28812.6	65
		423	44°23'	60°46'	13827.6	28849.4	64
		424	44°28'	60°52'	13854.3	28900.5	77
		425	44°33'	60°39'	13880.3	28850.0	61
		426	44°37'	60°33'	13904.4	28900.0	69
		427	44°39'	60°27'	13911.4	28799.6	46
		428	44°44'	60°27'	13939.0	28750.6	81
		429	44°41'	60°33'	13926.1	28699.8	61
		430	44°36'	60°00'	13901.0	28702.5	38
		431	44°34'	60°39'	13889.3	28751.9	40
		432	44°30'	60°33'	13878.0	28799.2	47
		433	44°28'	60°27'	13856.1	28797.3	51
		434	44°24'	60°20'	13839.2	28747.9	44
		435	44°22'	60°27'	13827.4	28699.4	44
		436	44°24'	60°20'	13842.3	28647.6	52
		437	44°29'	60°27'	13866.2	28701.4	33
		438	44°34'	60°20'	13888.2	28649.1	65
Middle	1982	318	44°33'	60°53'	13879.7	28907.9	70
		319	44°28'	60°45'	13855.1	28838.0	55
		320	44°29'	60°33'	13861.6	28747.3	41
		321	44°37'	60°30'	13903.9	28725.1	32
		322	44°33'	60°26'	13882.5	28693.8	31
		323	44°26'	60°23'	13848.9	28693.8	43
		324	44°25'	60°27'	13844.8	28702.6	29
Banquereau	1981	439	44°28'	59°52'	13865.0	28423.4	57
		441	44°37'	59°46'	13879.9	28374.5	61
		442	44°27'	59°36'	13864.2	28300.9	68
		443	44°32'	59°29'	13885.6	28246.1	59
		443	44°32'	59°29'	13885.6	28246.1	48
		444	44°28'	59°23'	13869.9	28195.1	57
		445	44°27'	59°10'	13868.9	28097.3	71
		446	44°25'	59°00'	13861.9	28016.2	61
		447	44°28'	58°51'	13872.3	27948.3	71
		448	44°23'	58°44'	13856.4	27900.9	64
		449	44°19'	58°50'	13839.5	27950.8	71
		450	44°44'	58°56'	13812.4	28000.9	63
		451	44°11'	58°49'	13802.7	27950.2	61
		452	44°09'	58°43'	13797.2	27902.6	62
		453	44°16'	58°43'	13862.5	27897.1	63
		454	44°15'	58°34'	13820.9	27825.4	65
		455	44°21'	58°38'	13848.1	27851.1	65
		456	44°29'	58°39'	13882.4	27850.4	70
		457	44°26'	58°32'	13820.1	27797.7	67

...Cont'd.



Table 5. Cont'd.

Bank	Year	Station	Lat.	Long.	Loran X	Loran Y	Depth (m)
St. Anns	1983	47*	46°32'	59°49'			
		48*	46°32'	59°41'			
		49*	46°54'	59°49'			
		50*	46°29'	59°56'			
		51	46°27'	59°48'	14388.1	28367.6	61
		52*	46°26'	59°41'			
Georges	1980	178	41°22'	66°55'	13050.5	43650.5	65
		179	41°13'	65°55'	13089.4	43608.5	65
		180	41°05'	66°54'	13121.0	43564.6	65
		181	40°75'	66°54'	13160.6	43520.8	78
		182	41°00'	67°12'	13218.7	43550.4	71
		183	41°03'	67°30'	13276.7	43579.4	62
		184	40°54'	67°30'	13317.0	43529.9	89
		185	40°46'	67°30'	13352.6	43486.7	80
		186	40°46'	67°44'	13412.3	43495.6	62
		187	40°46'	68°00'	13480.5	43505.9	17
		188	40°46'	68°12'	13539.7	43513.2	55
		189	40°29'	69°33'	13993.9	43470.6	64
Georges	1981	474	41°50'	66°43'	12865.2	43776.9	69
		475	41°52'	66°53'	12899.2	43793.7	66
		476	42°08'	66°56'	12826.4	43874.9	67
		477	42°06'	67°07'	12878.5	43883.5	58
		478	42°02'	67°19'	12949.5	43872.4	50
		479	42°02'	67°36'	13020.8	43890.4	64
		480	41°55'	67°36'	13059.3	43851.8	38
		481	41°53'	67°24'	13017.9	43830.6	63
		482	41°52'	67°12'	12975.3	43811.4	57
		483	41°42'	67°12'	13016.8	43771.0	54
		484	41°45'	67°42'	13055.5	43792.6	41
		485	41°43'	67°29'	13086.7	43790.1	48
		486	41°42'	67°34'	13116.9	43786.3	36
		487	41°35'	67°26'	13112.7	43743.0	37
		488	41°28'	67°18'	13111.7	43705.5	44
		489	41°23'	67°10'	13105.1	43668.4	50
		490	41°23'	67°26'	13169.6	43680.1	42
		491	41°27'	67°35'	13187.2	43714.6	30
		492	41°19'	67°14'	13254.1	43670.9	38
		493	41°11'	67°46'	13312.6	43632.5	43
		494	41°04'	67°51'	13367.9	43595.2	49
		495	40°58'	67°58'	13424.3	43566.6	57
		496	41°06'	68°01'	13403.8	43617.5	51
		497	41°12'	67°59'	13369.7	43648.1	41
		498	41°18'	67°54'	13315.9	43685.1	32
		499	41°24'	68°01'	13321.1	43721.9	40
		500	41°32'	67°58'	13268.6	43759.4	32

...Cont'd.



Table 5. Cont'd.

Bank	Year	Station	Lat.	Long.	Loran X	Loran Y	Depth (m)
Banquereau	1981	458	44°23'	58°25'	13859.6	27750.1	64
		459	44°16'	58°24'	13829.5	27750.3	63
		460	44°18'	58°11'	13840.0	27650.2	60
		461	44°21'	58°18'	13851.1	27699.9	62
		462	44°27'	58°19'	13877.6	27697.1	62
		463	44°25'	58°13'	13869.8	27649.9	64
		464	44°23'	58°04'	13862.3	27592.2	50
		465	44°27'	57°59'	13880.0	27545.1	49
		466	44°28'	57°53'	13885.5	27493.9	36
		467	44°33'	57°55'	13908.2	27507.5	46
		468	44°38'	58°02'	13921.8	27551.2	56
		469	44°43'	58°09'	13940.2	27600.7	70
		470	44°38'	58°21'	13920.2	27699.4	56
		471	44°37'	58°40'	13914.7	27854.2	76
		472	44°32'	58°55'	13893.8	27980.7	55
		473	44°33'	59°17'	13896.9	28149.7	60
Banquereau	1982	273	44°31'	59°06'	13888.8	28060.3	54
		274	44°36'	59°04'	13908.0	28044.4	76
		275	44°38'	58°53'	13915.4	27947.2	69
		276	44°34'	58°46'	13899.1	27896.1	65
		277	44°35'	58°33'	13905.6	27796.1	62
		278	44°42'	58°28'	13935.9	27750.3	66
		279	44°31'	58°26'	13889.7	27751.0	62
		280	44°21'	58°30'	13845.8	27788.4	60
		281	44°30'	58°07'	13886.5	27601.2	57
		282	44°33'	58°17'	13900.0	27677.6	65
		283	44°38'	58°11'	13919.4	27646.1	65
		284	44°47'	58°16'	13596.7	27646.1	68
		285	44°53'	58°04'	13978.9	27546.7	65
		286	44°46'	58°02'	13953.5	27545.9	63
		287	44°43'	57°56'	13940.2	27497.5	50
		288	44°39'	57°49'	13926.5	27451.8	32
		289	44°43'	57°41'	13905.8	27398.8	57
		290	44°28'	57°46'	13882.4	27445.1	72
		291	44°28'	57°33'	13883.9	27344.5	69
		292	44°31'	57°22'	13900.4	27250.7	66
		293	44°35'	57°29'	13914.3	27297.0	54
		294	44°39'	57°36'	13927.1	27346.3	51
		295	44°42'	57°43'	13940.6	27389.4	28
		296	44°46'	57°50'	13955.4	27448.2	41
		297	44°49'	47°57'	13966.9	27498.8	56
		298	44°44'	57°57'	13989.9	27499.6	66
		299	44°50'	47°44'	13969.4	27496.0	38

...Cont'd.

Table 5. Cont'd.

Bank	Year	Station	Lat.	Long.	Loran X	Loran Y	Depth (m)
Georges	1981	501	41°39'	67°54'	13214.6	43797.1	34
		502	41°44'	68°02'	13227.0	43832.1	38
		503	41°46'	68°12'	13267.5	43850.9	72
		504	41°40'	68°19'	13329.7	43821.5	50
		505	41°34'	68°13'	13328.9	43785.3	37
		506	41°27'	68°14'	13364.7	43747.7	47
		507	41°28'	68°24'	13409.8	43763.5	66
		508	41°20'	68°29'	13466.7	43723.7	68
		509	41°19'	68°16'	13413.4	43704.2	55
		510	41°13'	68°08'	13403.9	43665.9	41
		511	41°05'	68°14'	13466.8	43625.8	43
		512	40°56'	68°14'	13507.1	43574.0	50
		513	40°48'	68°26'	13592.8	43538.0	55
		514	40°39'	68°26'	13631.6	43478.7	65
		515	40°35'	68°40'	13713.2	43461.1	66
		516	40°45'	68°40'	13686.9	43528.9	66
Georges	1982	368	41°50'	66°50'	12893.2	43788.1	65
		369	41°43'	66°27'	12844.6	43730.1	72
		370	41°37'	66°45'	12940.5	43718.5	66
		371	41°37'	66°34'	12899.2	43707.4	71
		372	41°37'	66°55'	12977.4	43726.1	60
		373	41°37'	67°05'	13021.9	43735.6	54
		374	41°27'	66°55'	13024.0	43676.9	65
		375	41°27'	66°44'	12985.9	43667.6	73
		376	41°15'	66°45'	13040.8	43607.0	71
		377	41°15'	66°55'	13080.9	43615.4	65
		378	41°16'	67°06'	13125.1	43625.4	55
		379	41°14'	67°14'	13172.2	43621.1	51
		380	41°05'	67°06'	13169.9	43569.8	62
		381	41°05'	66°36'	13128.3	43564.0	67
		382	41°06'	66°44'	13082.6	43558.9	74
		383	40°59'	66°57'	13162.2	43530.6	69
		384	41°03'	67°16'	13223.8	43562.9	64
		385	41°09'	67°33'	13266.1	4361.01	49
		386	41°21'	67°30'	13197.2	43675.6	30
		487	41°26'	67°41'	13222.2	43712.4	28
		388	41°36'	67°35'	13150.9	43755.5	33
		389	41°42'	67°44'	13158.6	43799.0	27
		390	41°49'	67°43'	13165.2	43886.7	54
		391	41°54'	67°52'	13133.4	43868.0	53
		392	41°50'	68°00'	13187.4	43855.3	56
		393	41°37'	68°11'	13303.2	43779.6	15
		394	41°33'	68°26'	13397.6	43788.1	48
Georges	1983	520	41°20'	67°00'	13078.5	43643.0	65
		521	41°15'	67°15'	1316.13	43633.6	50
		522	41°10'	67°17'	13194.2	43603.1	56

...Cont'd.

Table 5. Cont'd.

Bank	Year	Station	Lat.	Long.	Loran X	Loran Y	Depth (m)
St. Anns	1983	1*	45°47'	60°01'			74
		2*	45°51'	60°00'			
		3*	45°52'	59°52'			
		4*	45°52'	59°47'			
		5*	45°51'	59°40'			
		6*	45°56'	59°44'			
		7*	45°56'	59°35'			
		8*	45°51'	59°34'			
		9*	45°52'	59°29'			
		10*	45°53'	59°22'			
		11*	45°56'	59°16'			
		12*	45°56'	59°29'			
		13*	45°59'	59°33'			
		14*	46°00'	59°38'			
		15*	46°03'	59°31'			
		16*	46°00'	59°26'			
		17*	46°00'	59°17'			
		18*	46°03'	59°22'			
		20*	46°06'	59°24'			
		21*	46°06'	59°30'			
		22*	46°06'	59°40'			
		23	46°08'	59°44'	14309.1	28335.2	43
		24*	46°10'	59°37'			
		25*	46°10'	59°31'			
		26*	46°11'	59°18'			
		27*	46°14'	59°43'			
		28*	46°15'	59°48'			
		29*	46°20'	59°42'			
		30*	46°21'	59°48'			34
		31*	46°17'	59°58'			
		32	46°17'	60°04'	14359.3	28510.2	
		33*	46°23'	59°56'			47
		34	46°23'	60°04'	14383.7	28545.1	
		35*	46°19'	60°12'			50
		36	46°22'	60°11'	14384.0	28565.6	
		37*	46°24'	60°16'			34
		38*	46°27'	60°22'			
		39	46°32'	60°23'	14432.7	28510.2	
		40*	46°38'	60°19'			
		41*	46°42'	60°18'			
		42*	46°41'	59°56'			
		43*	46°39'	59°56'			
		44*	46°38'	59°41'			
		45*	46°54'	59°48'			
		46*	46°30'	59°56'			

...Cont'd.

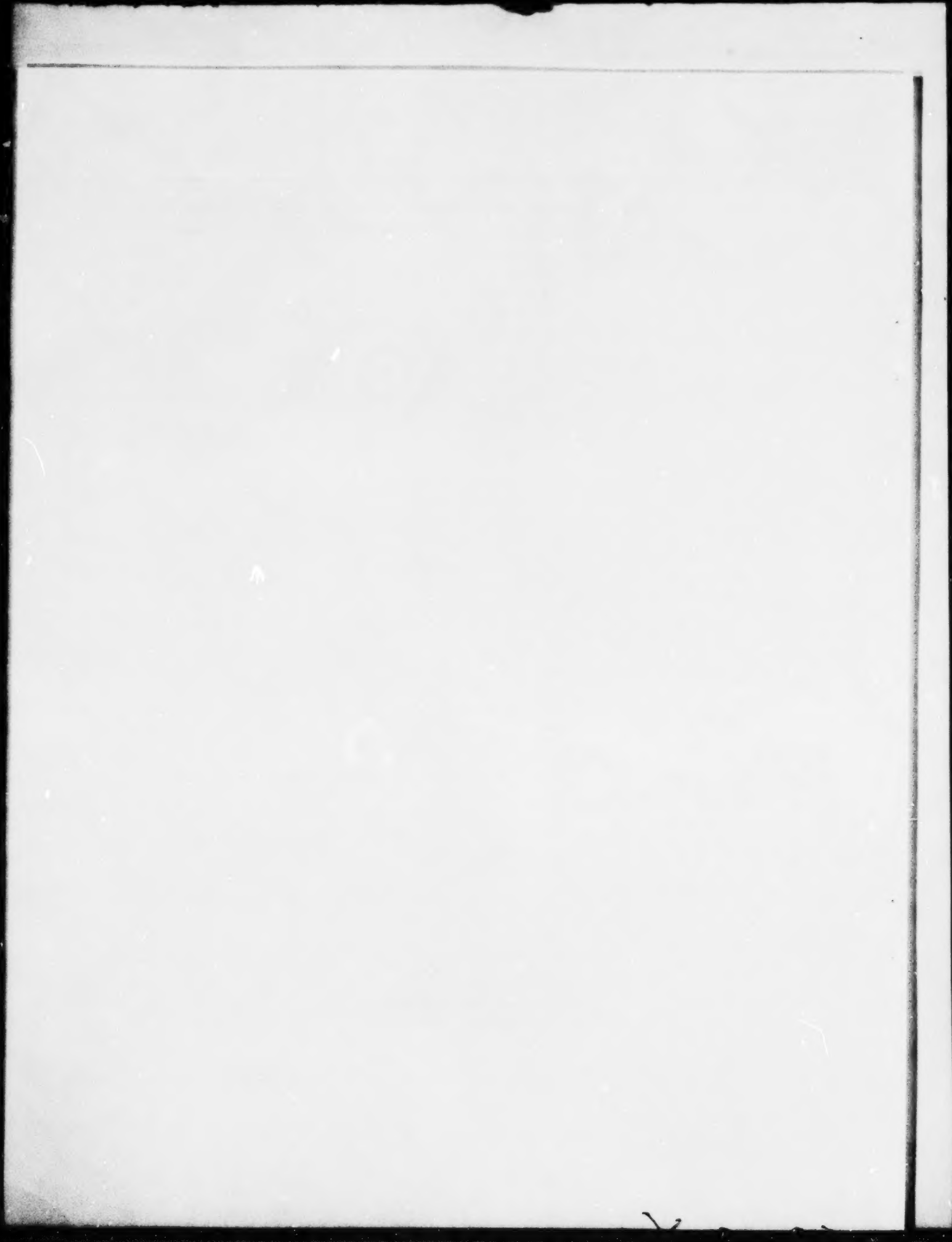


Table 5. Cont'd.

Bank	Year	Station	Lat.	Long.	Loran X	Loran Y	Depth (m)
Georges	1983	523*	40°55'	67°45'	13377.2	43544.6	
		524	40°55'	57°45'	13378.6	43542.1	64
		525	40°59'	67°36'	13323.3	43556.5	67
		526	41°06'	67°36'	13295.4	43598.5	56
		527	41°05'	67°25'	13251.1	43583.5	61
		528	41°11'	67°27'	13234.2	43516.5	49
		529	41°13'	67°29'	13231.6	43630.3	47
		530	41°18'	67°37'	13238.4	43665.9	43
		531	41°11'	67°43'	13298.8	43634.3	43
		532	41°18'	67°45'	13276.0	43672.5	31
		533	41°18'	67°57'	11656.1	31151.4	26
		534	41°09'	67°55'	11611.9	31112.4	52

*No Loran C coordinates and/or depth available for this station.





Fig. 1. Location of acoustical stations along the eastern shore of Nova Scotia (No. 1-9) and station locations preselected for dredge sampling on St. Anns Bank (No. 1-52).



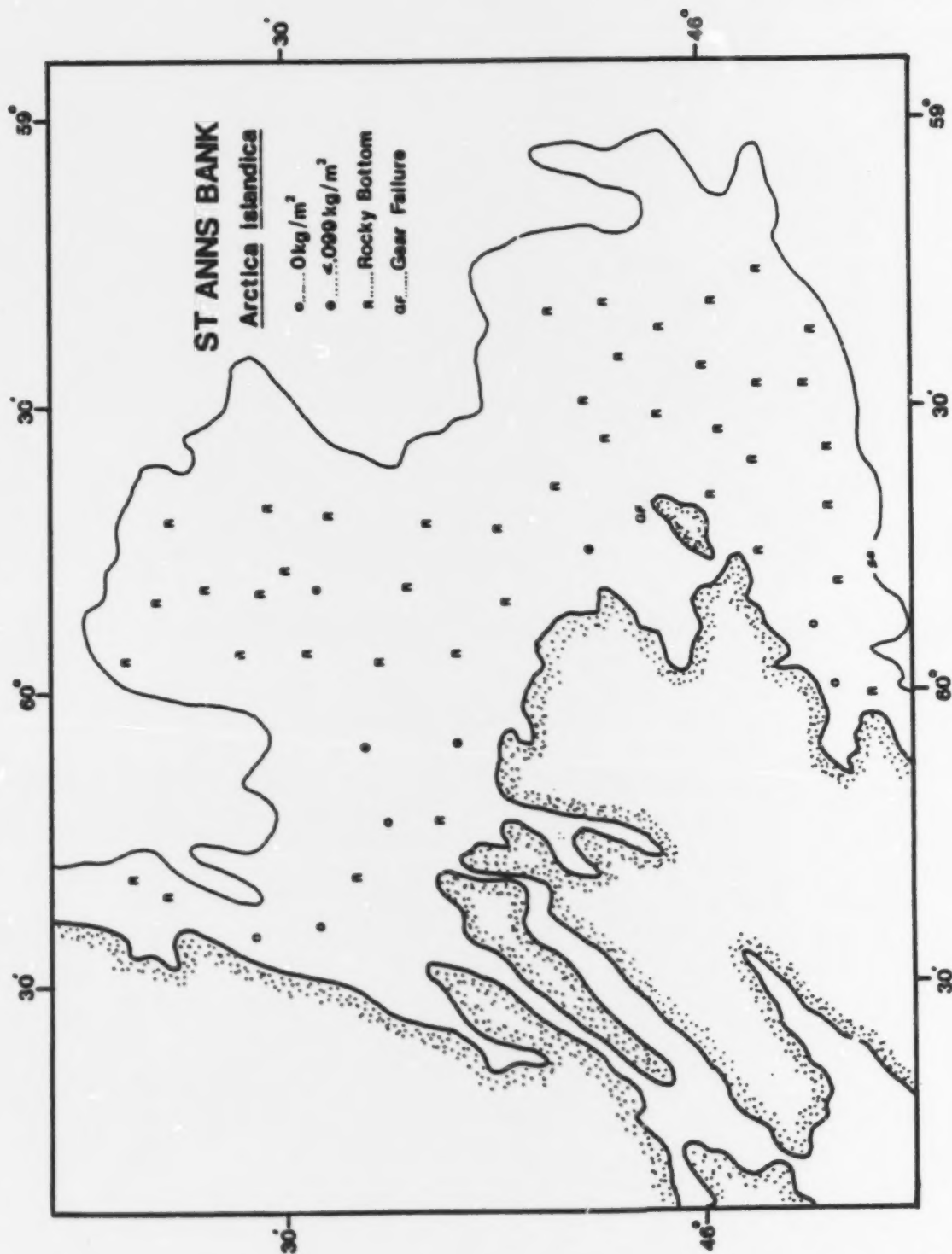


Fig. 2. Location of stations surveyed on St. Ann's Bank showing densities (kg/m²) of *A. islandica*.

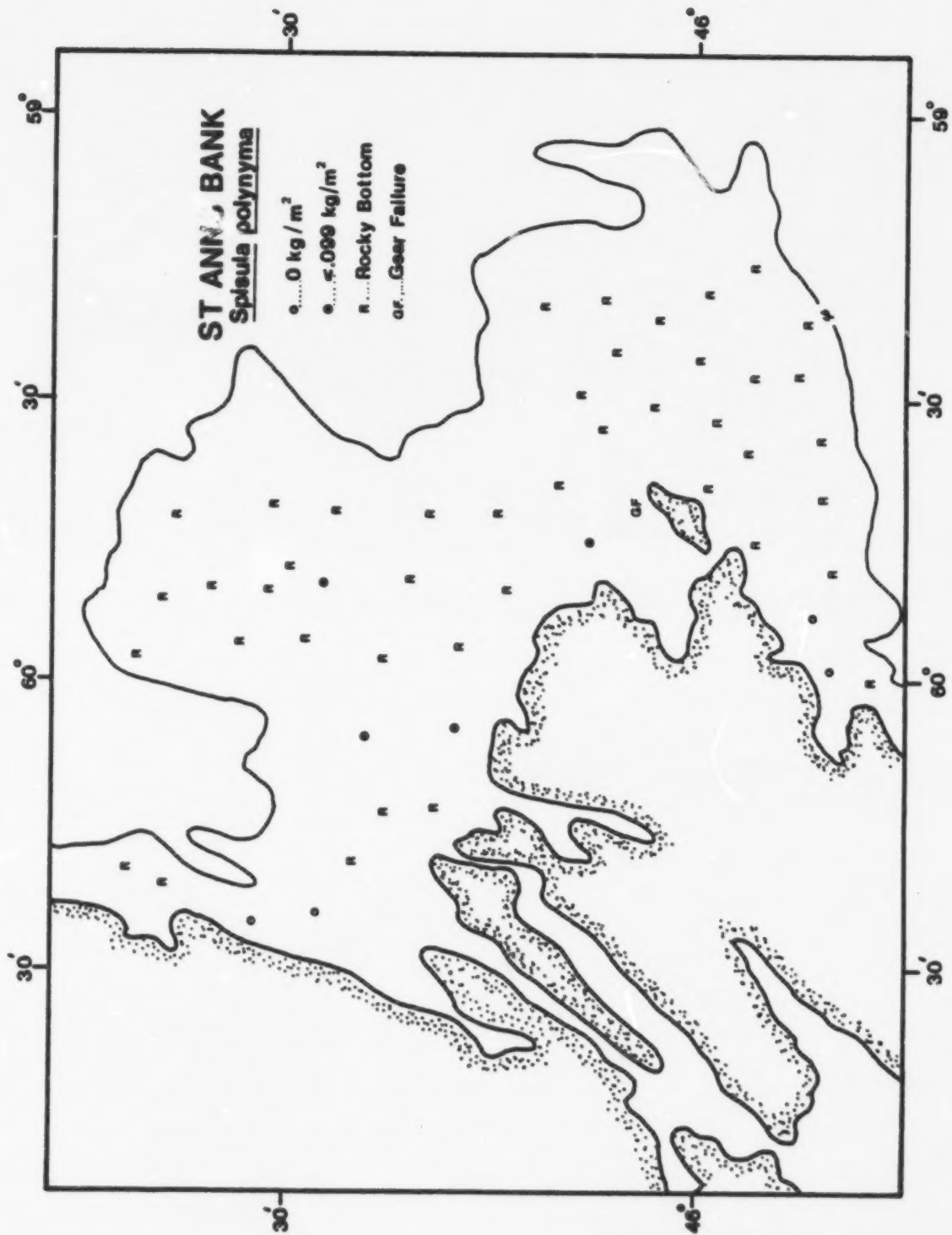


Fig. 3. Location of stations surveyed on St. Ann's Bank showing densities (kg/m²) of *S. polynyma*.

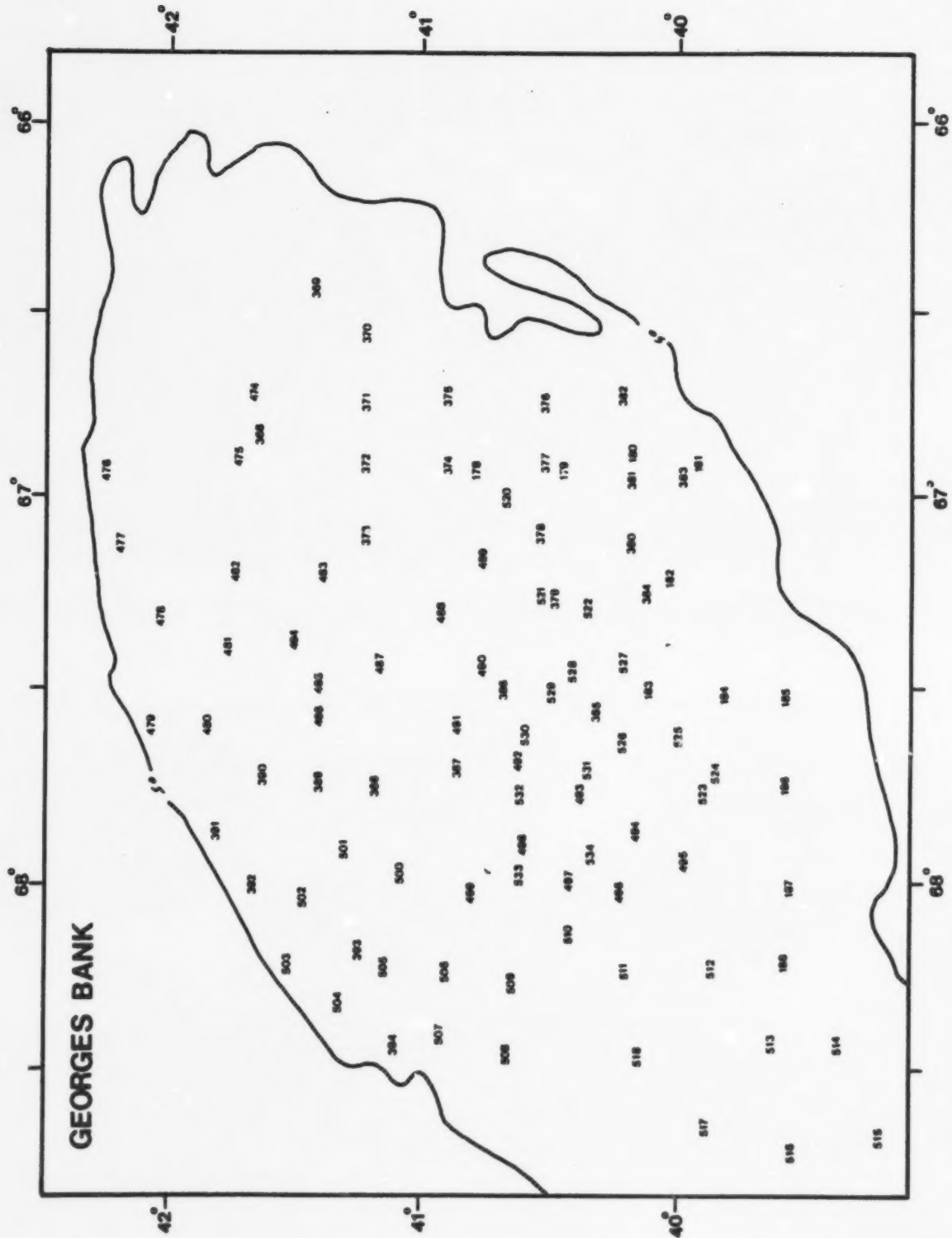


Fig. 4. Location of stations surveyed on Georges Bank in 1980, 1981, 1982, and 1983.

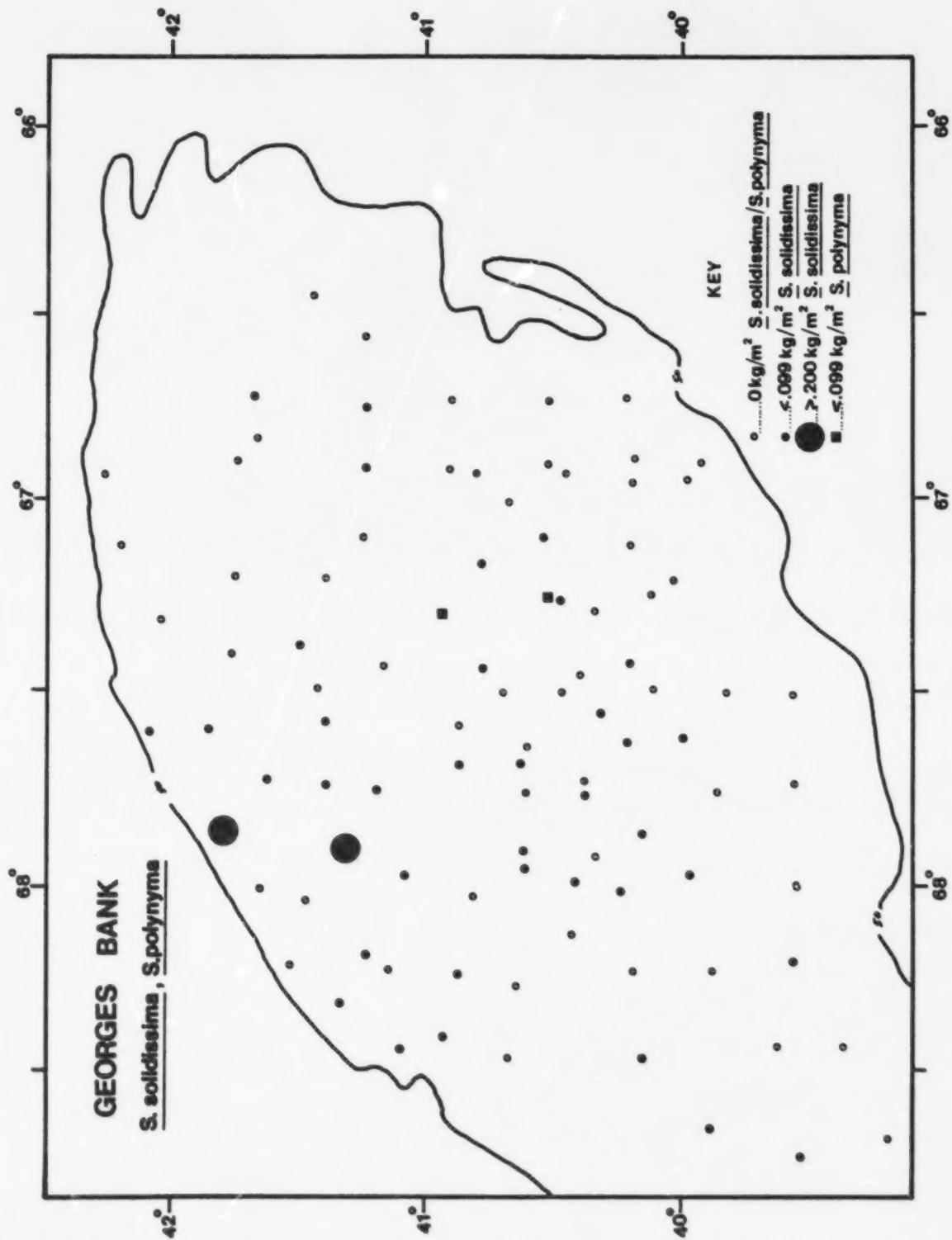


Fig. 5. Location of stations surveyed on Georges Bank showing densities (kg/m²) of S. solidissima and S. polynyma.

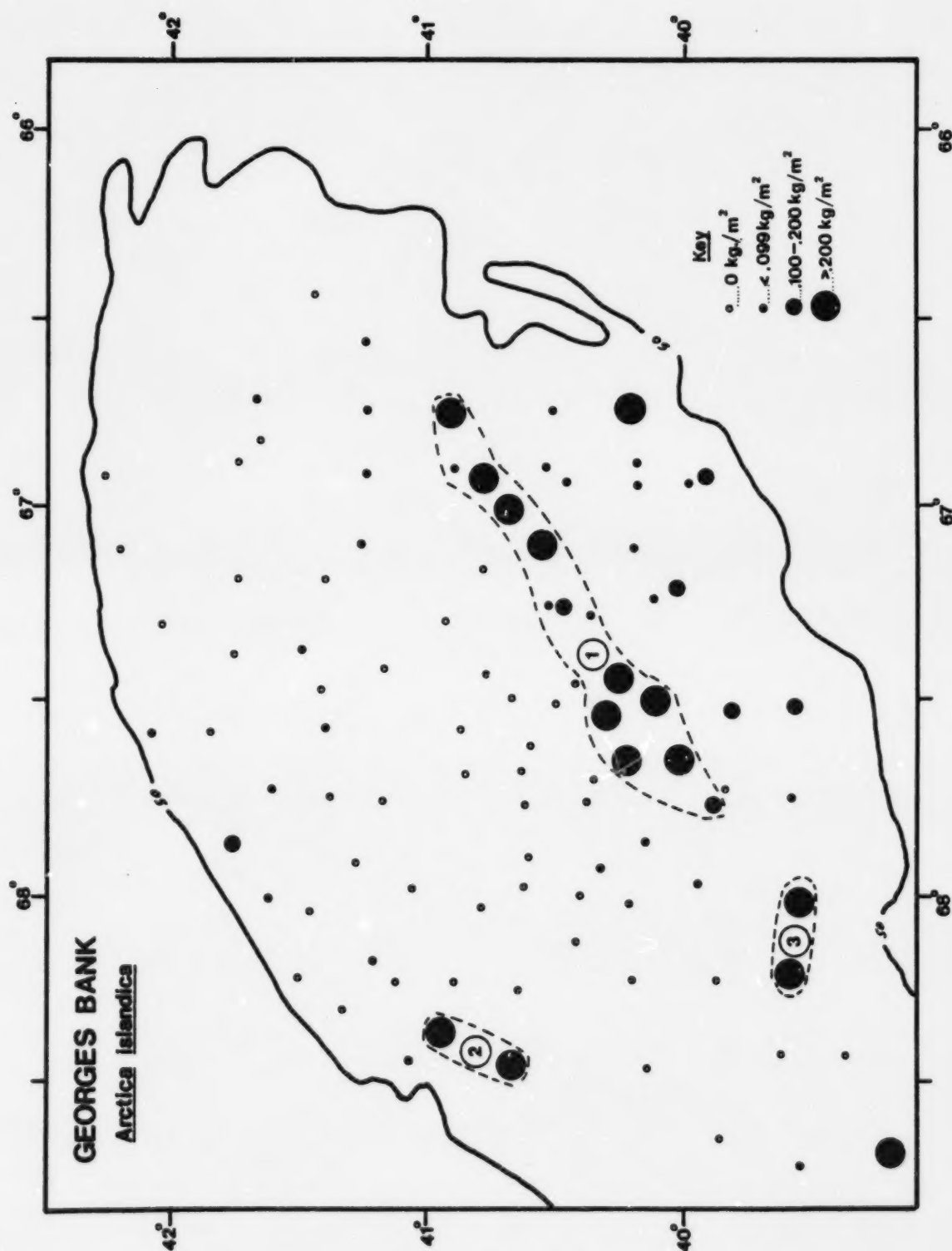


Fig. 6. Location of stations surveyed on Georges Bank showing densities (kg/m²) of A. islandica and boundaries of High-Catch Areas 1, 2, and 3.



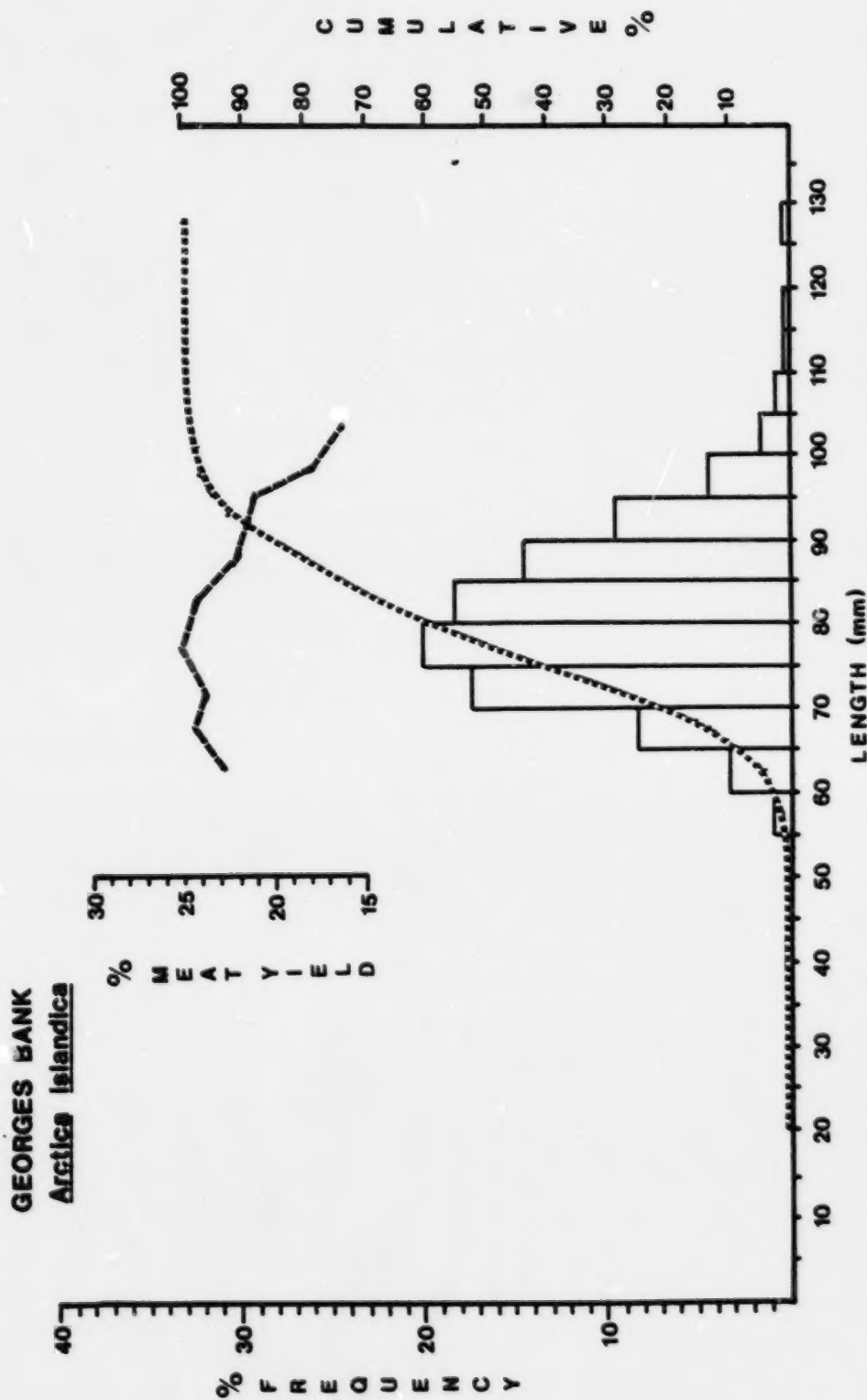


Fig. 7. Length frequency ($n=4268$), cumulative percent frequency, and percent meat yield ($n=94$) for each 5 mm size class of A. islandica on Georges Bank.

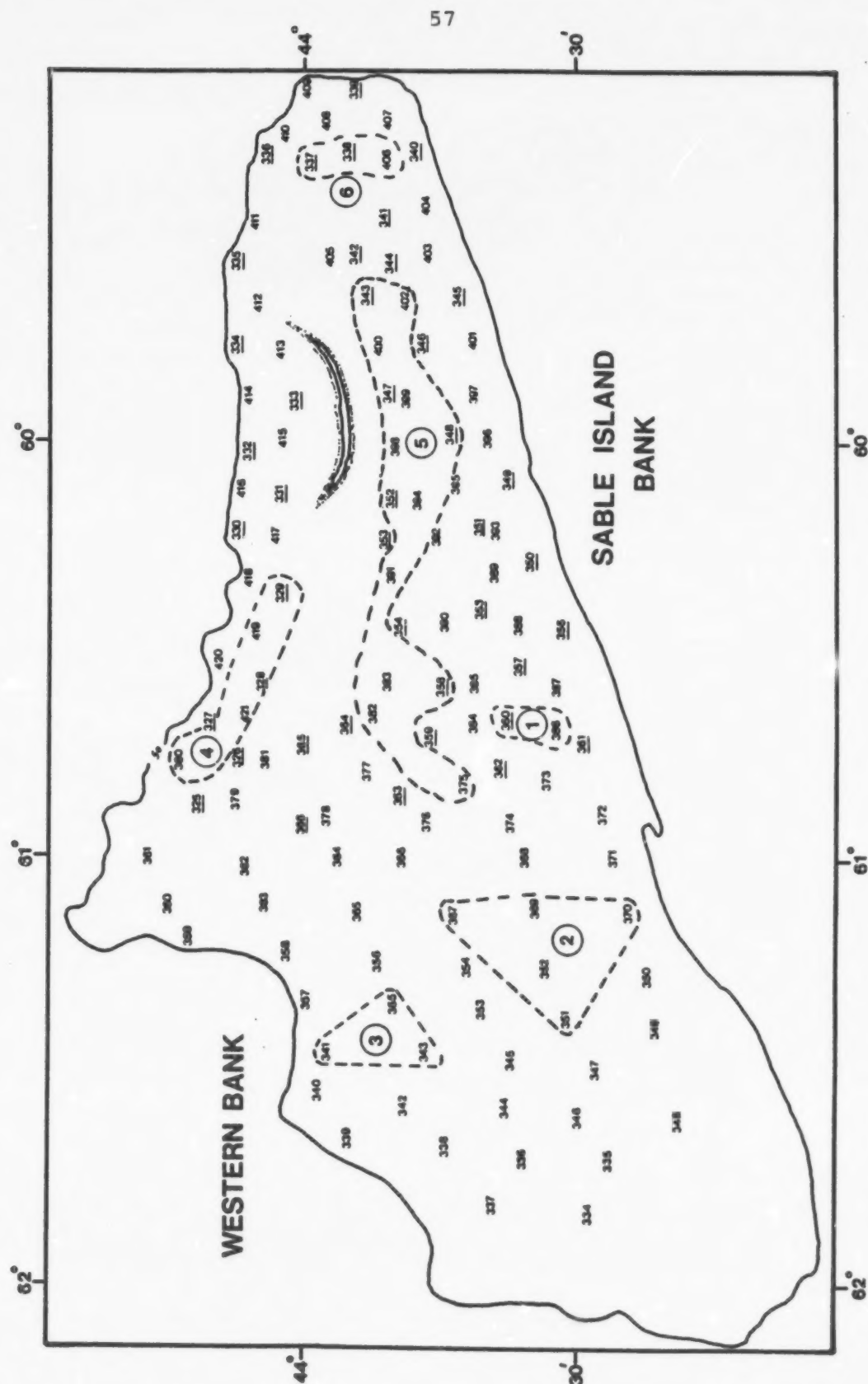


Fig. 8. Location of stations surveyed on Western and Sable Island Banks in 1981-1982 and boundaries of areas having greatest concentrations of *A. islandica* (1982 stations underlined).



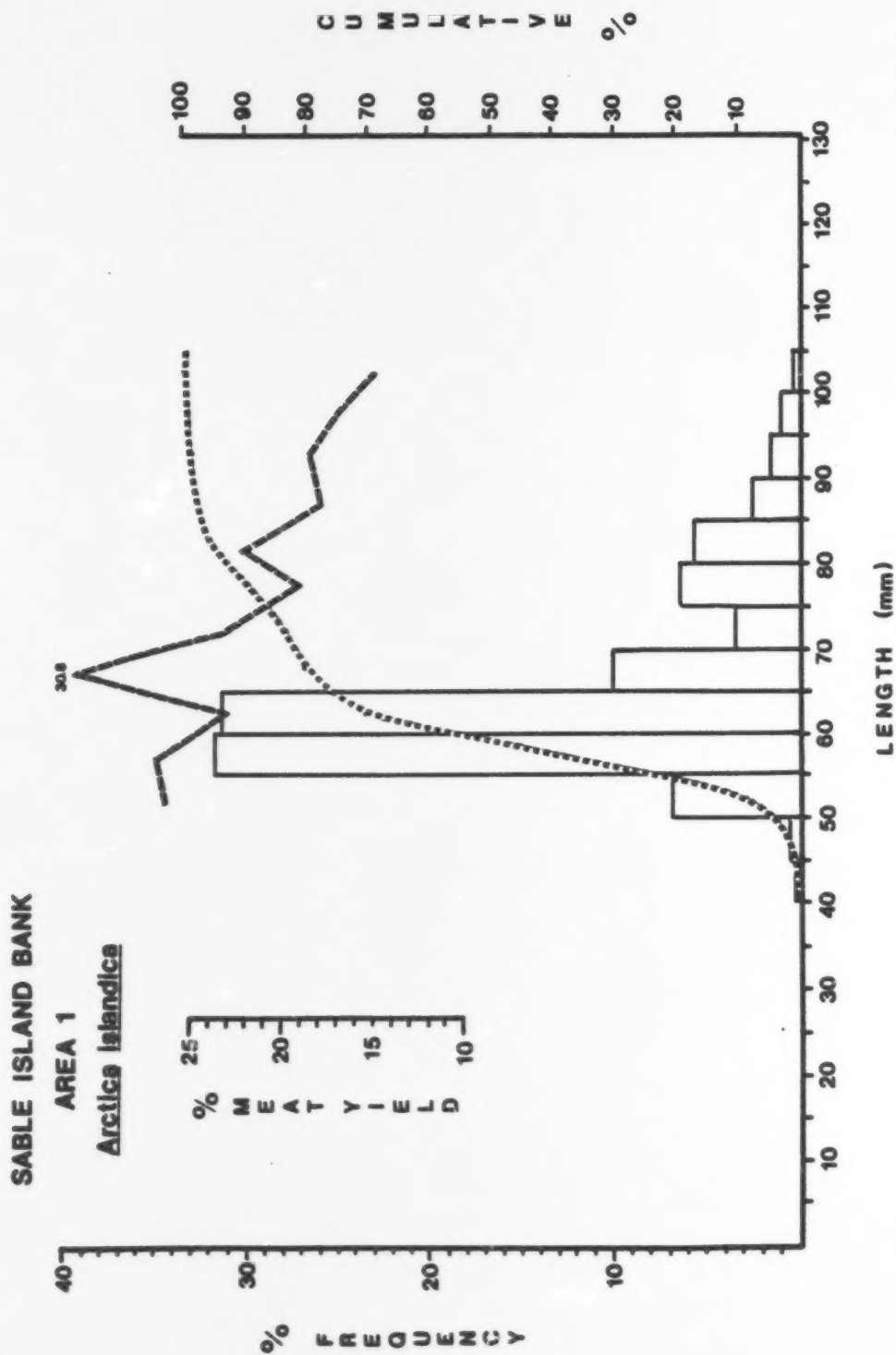


Fig. 9. Length frequency ($n=637$), cumulative percent frequency, and percent meat yield ($n=71$) for each 5 mm size class of A. islandica in Area 1 of Sable Island Bank.

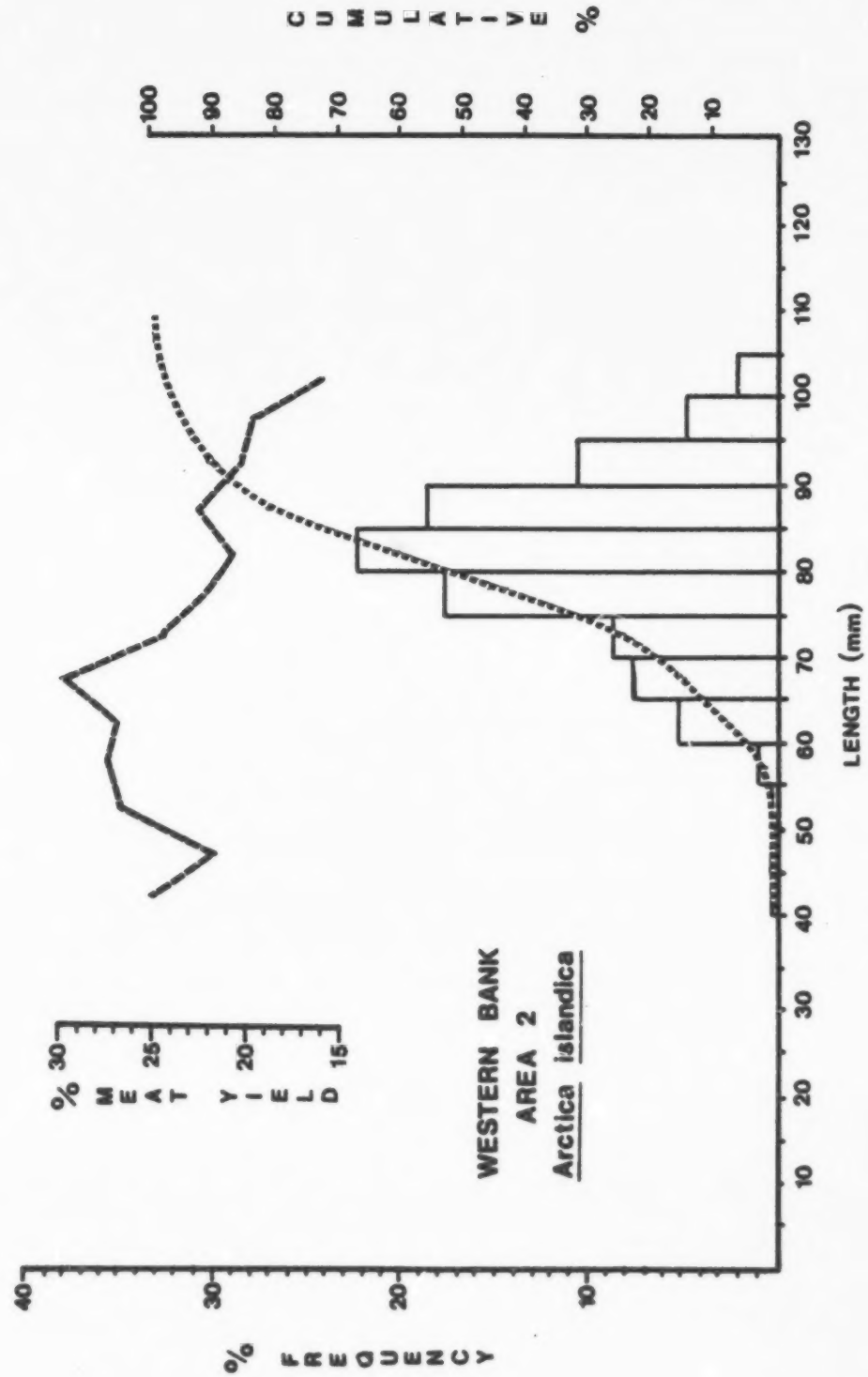


Fig. 10. Length frequency ($n=1228$), cumulative percent frequency, and percent meat yield ($n=139$) for each 5 mm size class of A. islandica in Area 2 of Western Bank.



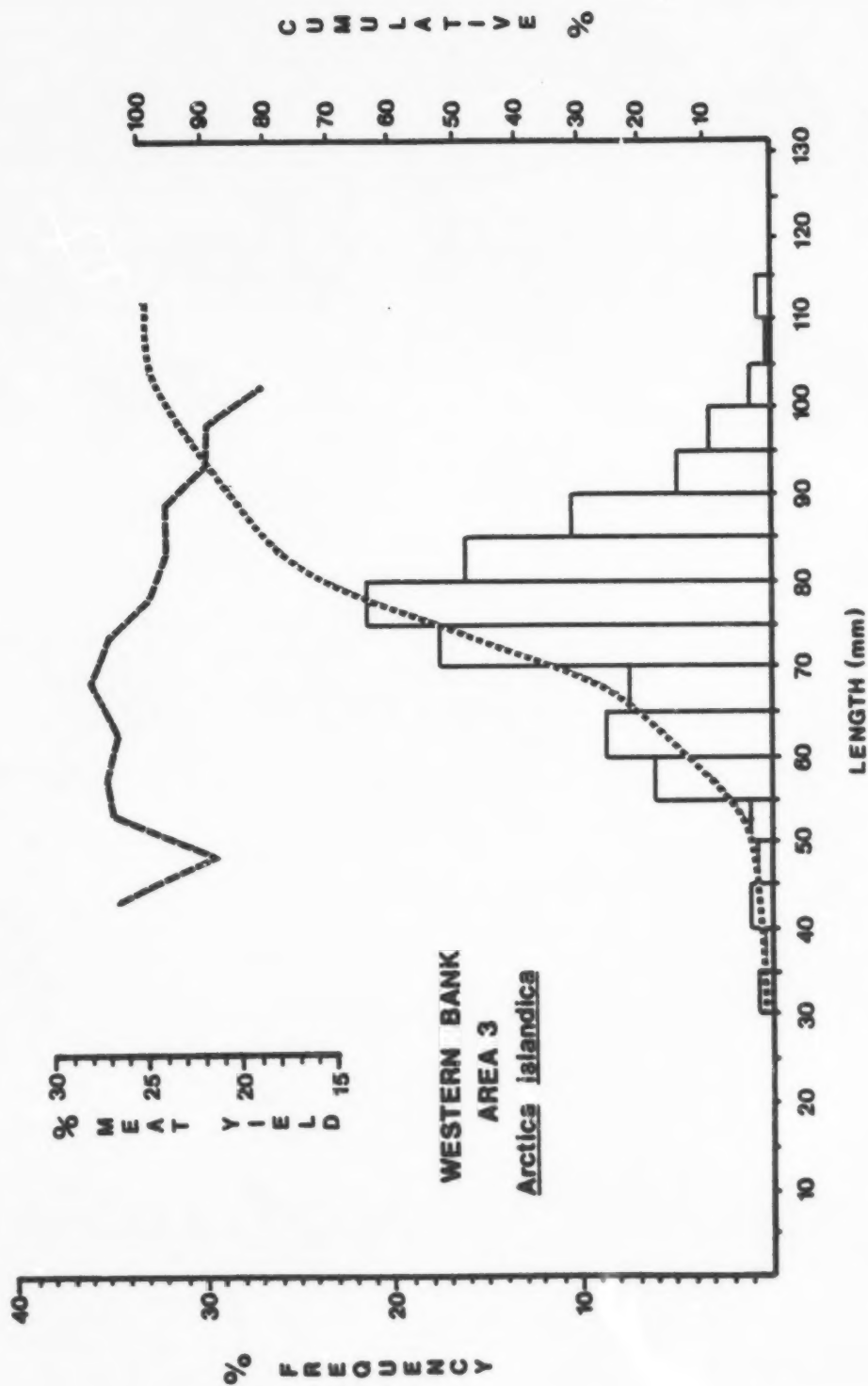


Fig. 11. Length frequency ($n=541$), cumulative percent frequency, and percent meat yield ($n=81$) for each 5 mm size class of A. islandica in Area 3 of Western Bank.



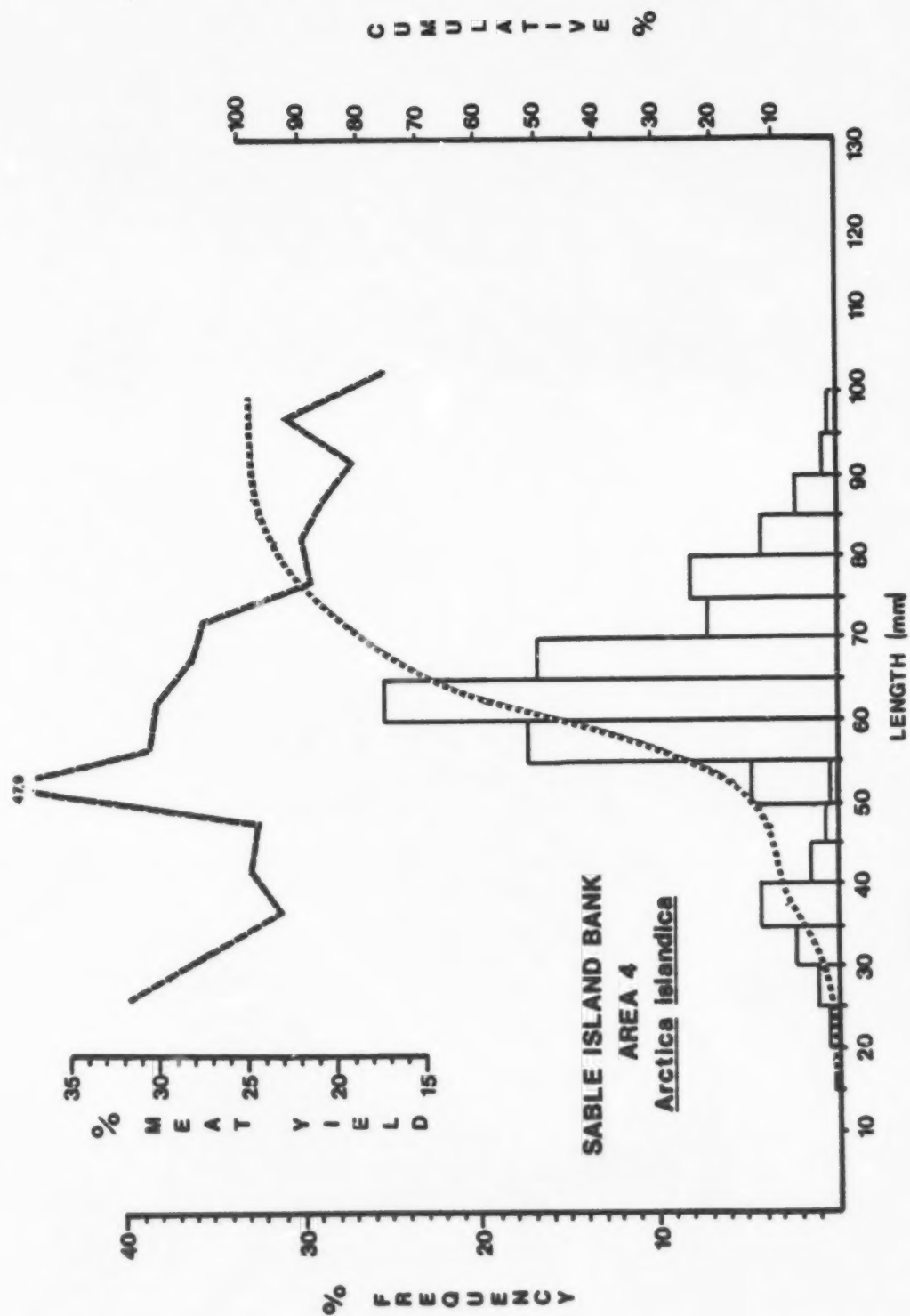


Fig. 12. Length frequency (n=1302), cumulative percent frequency, and percent meat yield (n=129) for each 5 mm size class of A. islandica in Area 4 of Sable Island Bank.



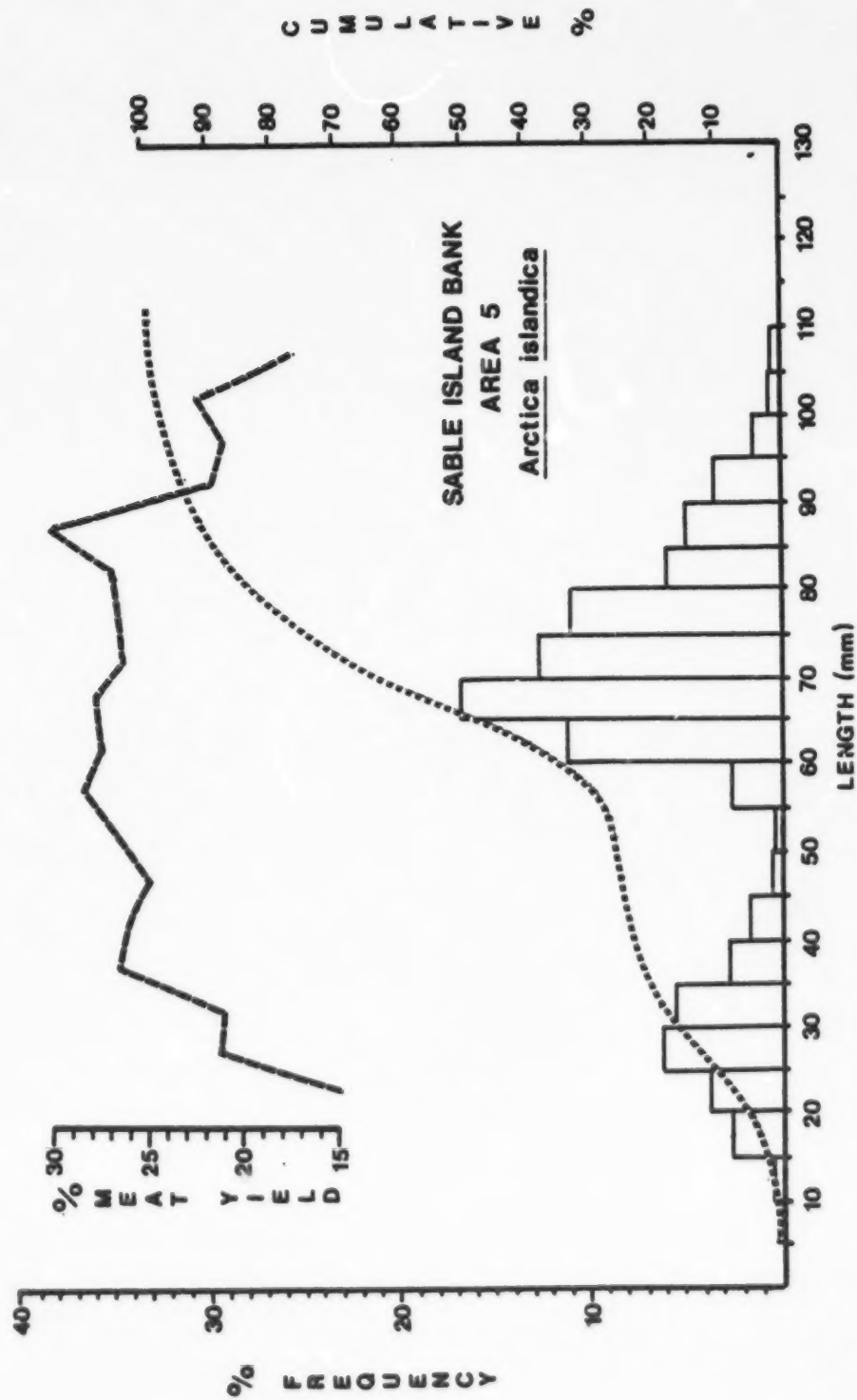


Fig. 13. Length frequency ($n=6253$), cumulative percent frequency, and percent meat yield ($n=492$) for each 5 mm size class of A. islandica in Area 5 of Sable Island Bank.



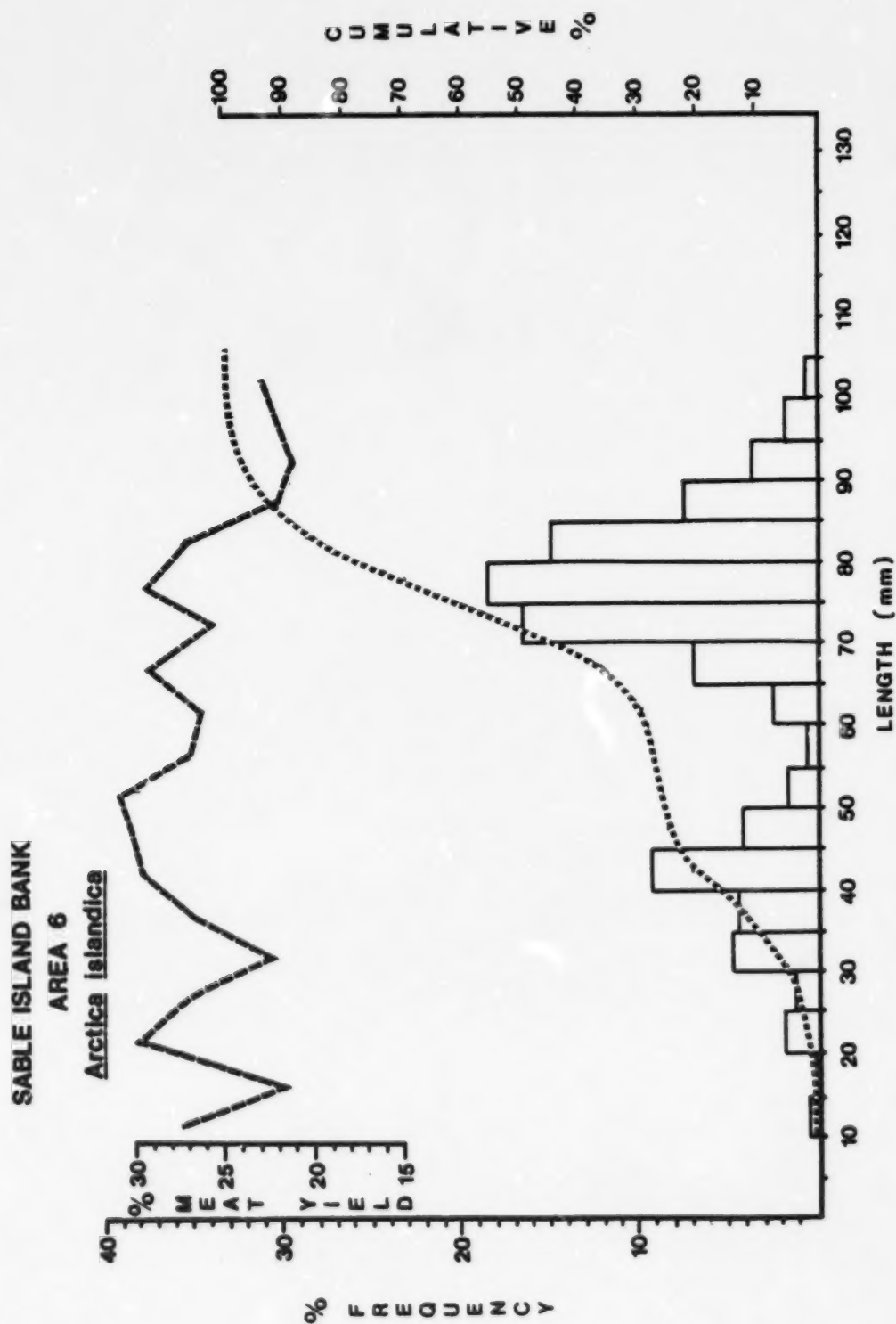


Fig. 14. Length frequency ($n=850$), cumulative percent frequency, and percent meat yield ($n=111$) for each 5 mm size class of A. islandica in Area 6 of Sable Island Bank.



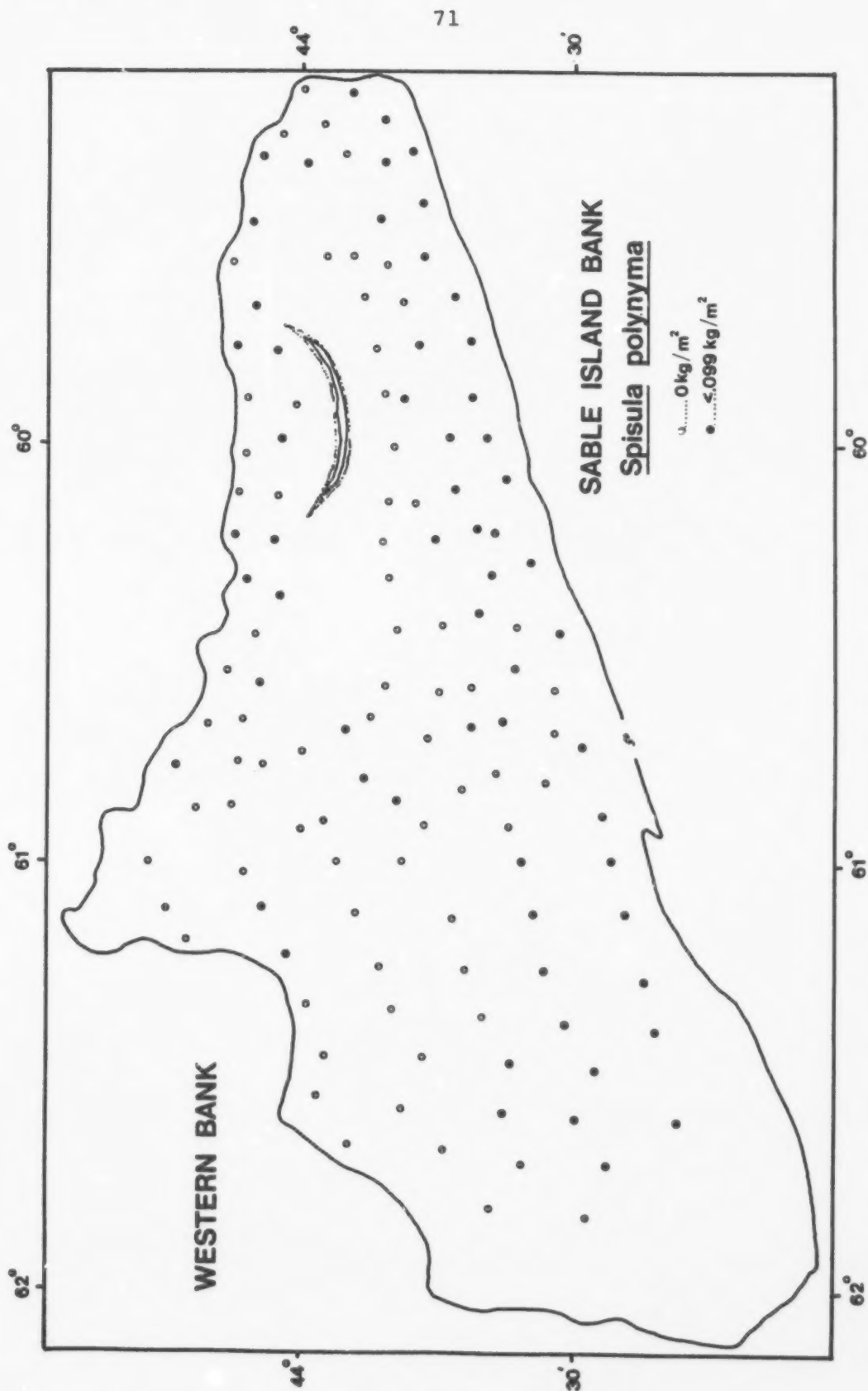


Fig. 15. Location of stations surveyed on Western and Sable Island Banks in 1981 and 1982 showing densities (kg/m²) of *S. polynyma*.



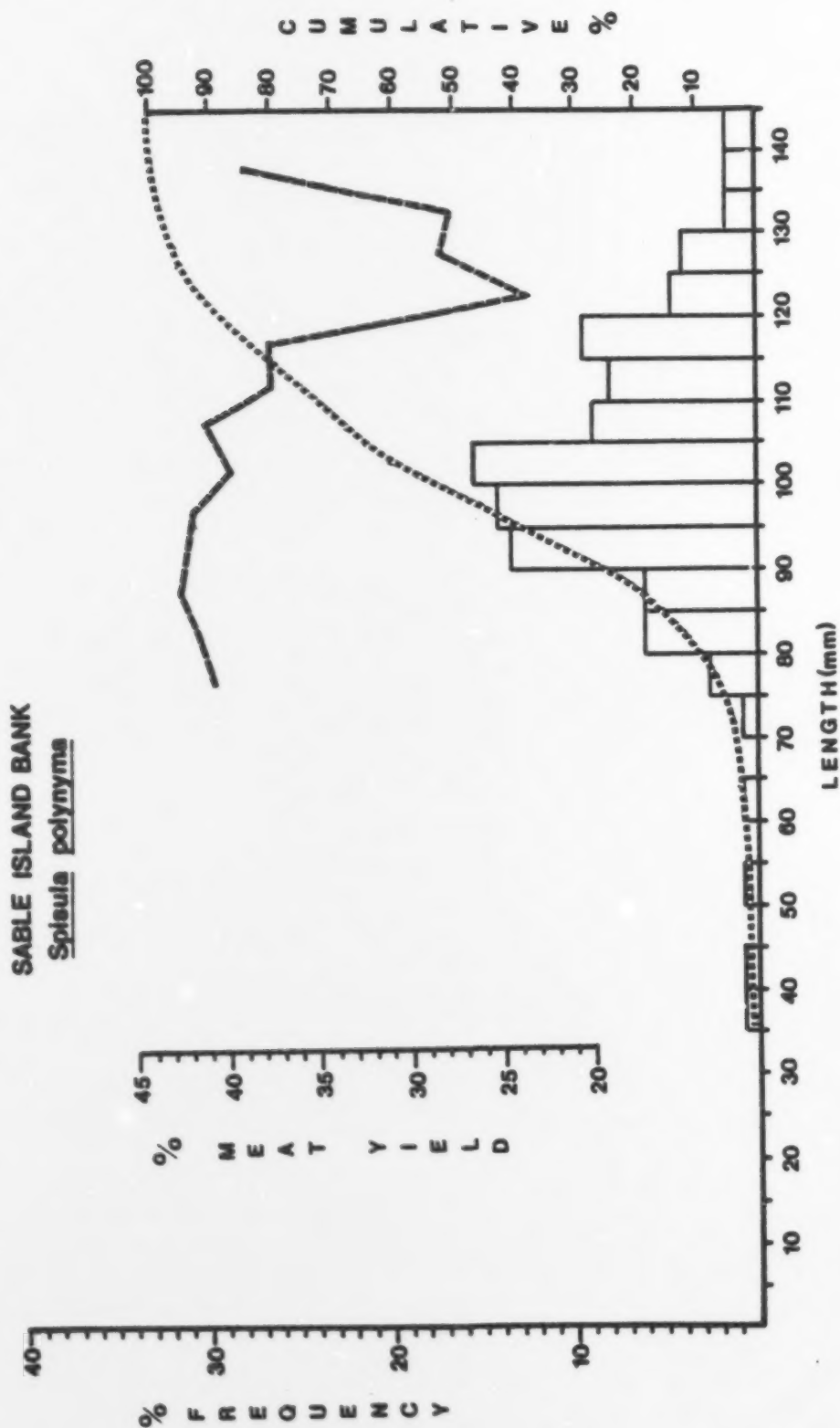


Fig. 16. Length frequency ($n=149$), cumulative percent frequency, and percent meat yield ($n=73$) for each 5 mm size class of S. polynyma on Western and Sable Island Banks.



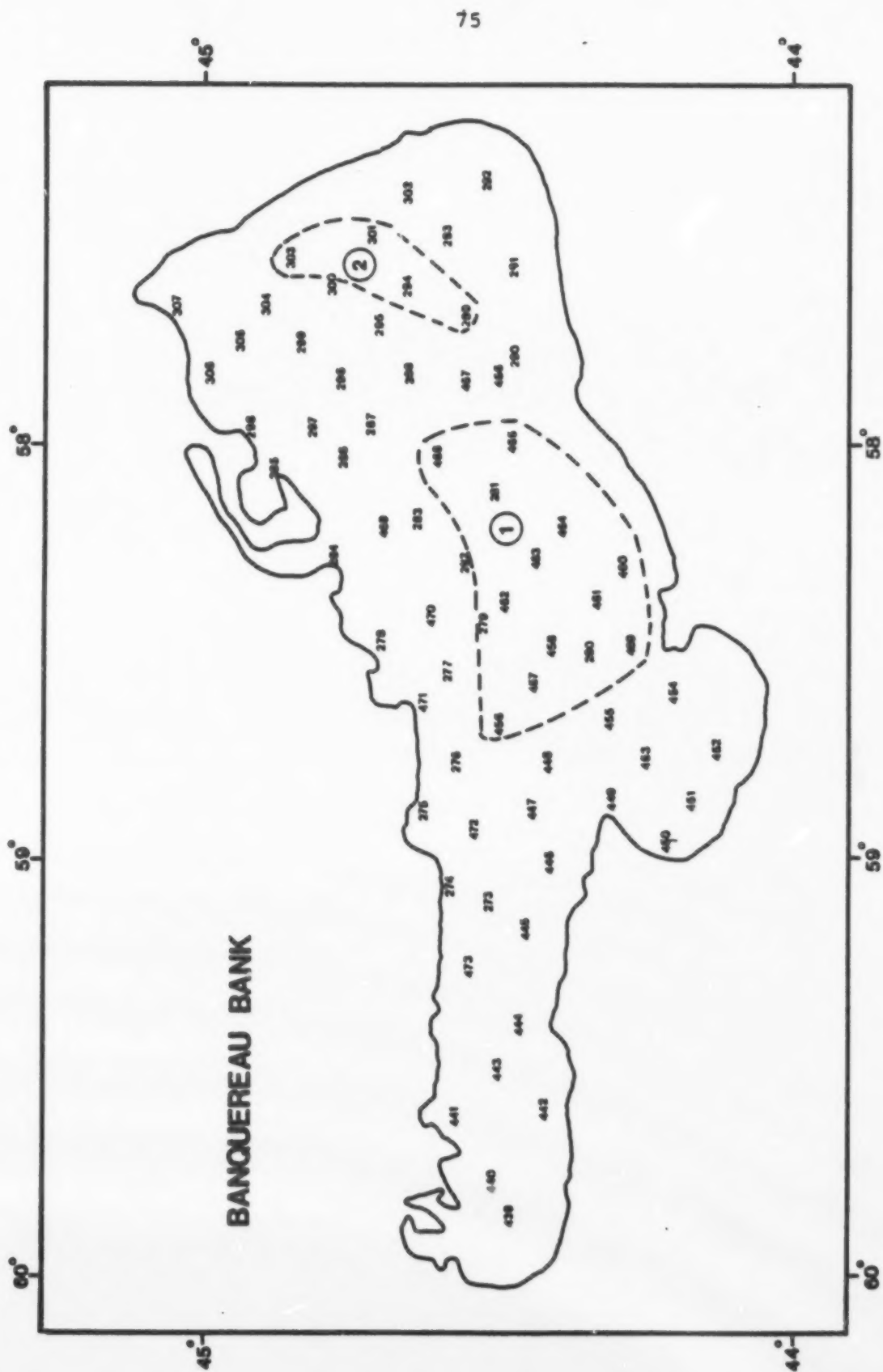


Fig. 17. Location of stations surveyed on Banquereau Bank in 1981-1982 showing the boundaries of areas having the most significant concentrations of S. polynyma.

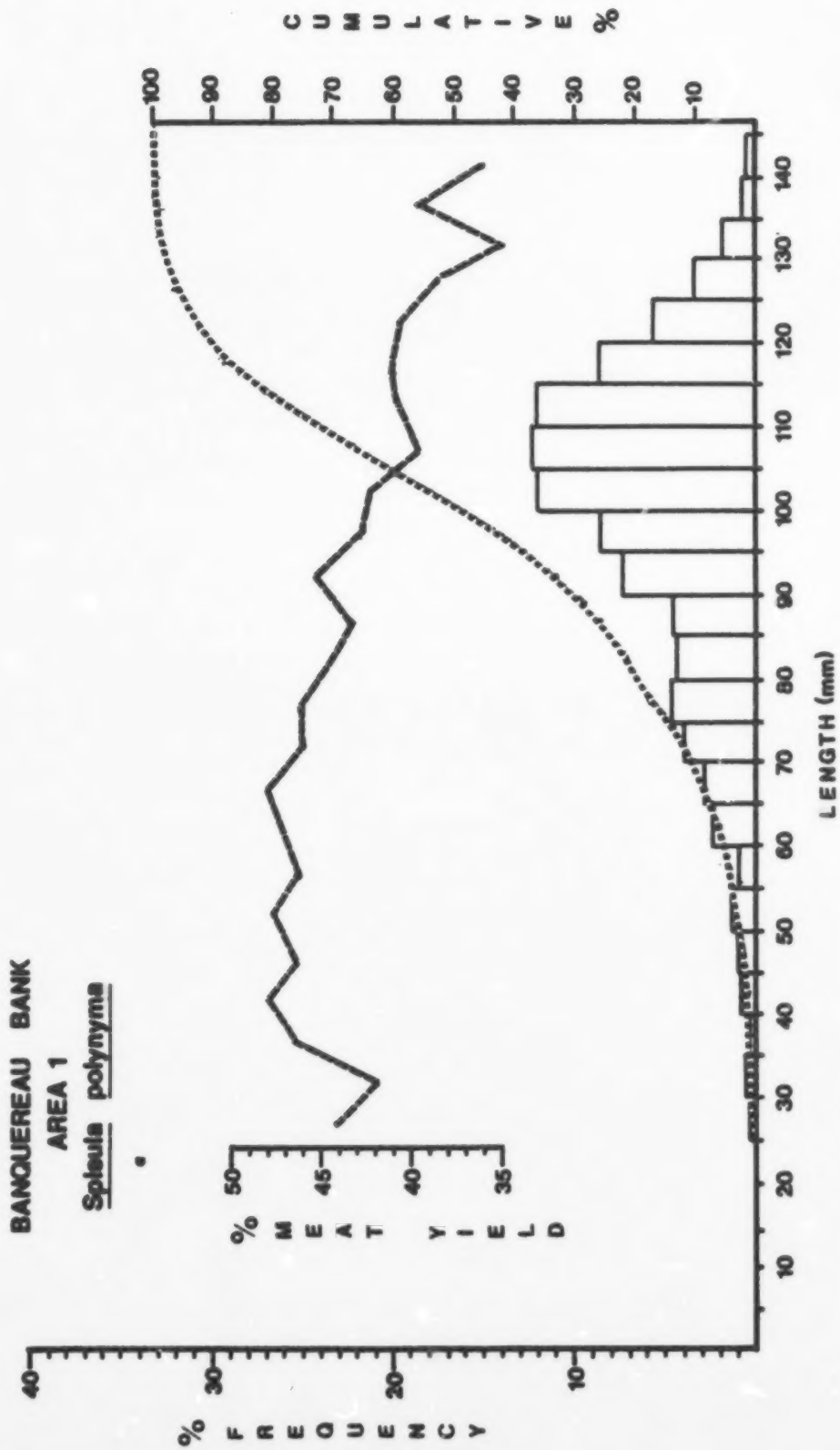


Fig. 18. Length frequency (n=1922), cumulative percent frequency, and percent meat yield (n=487) for each 5 mm size class of S. polynyma in Area 1 of Banquereau Bank.

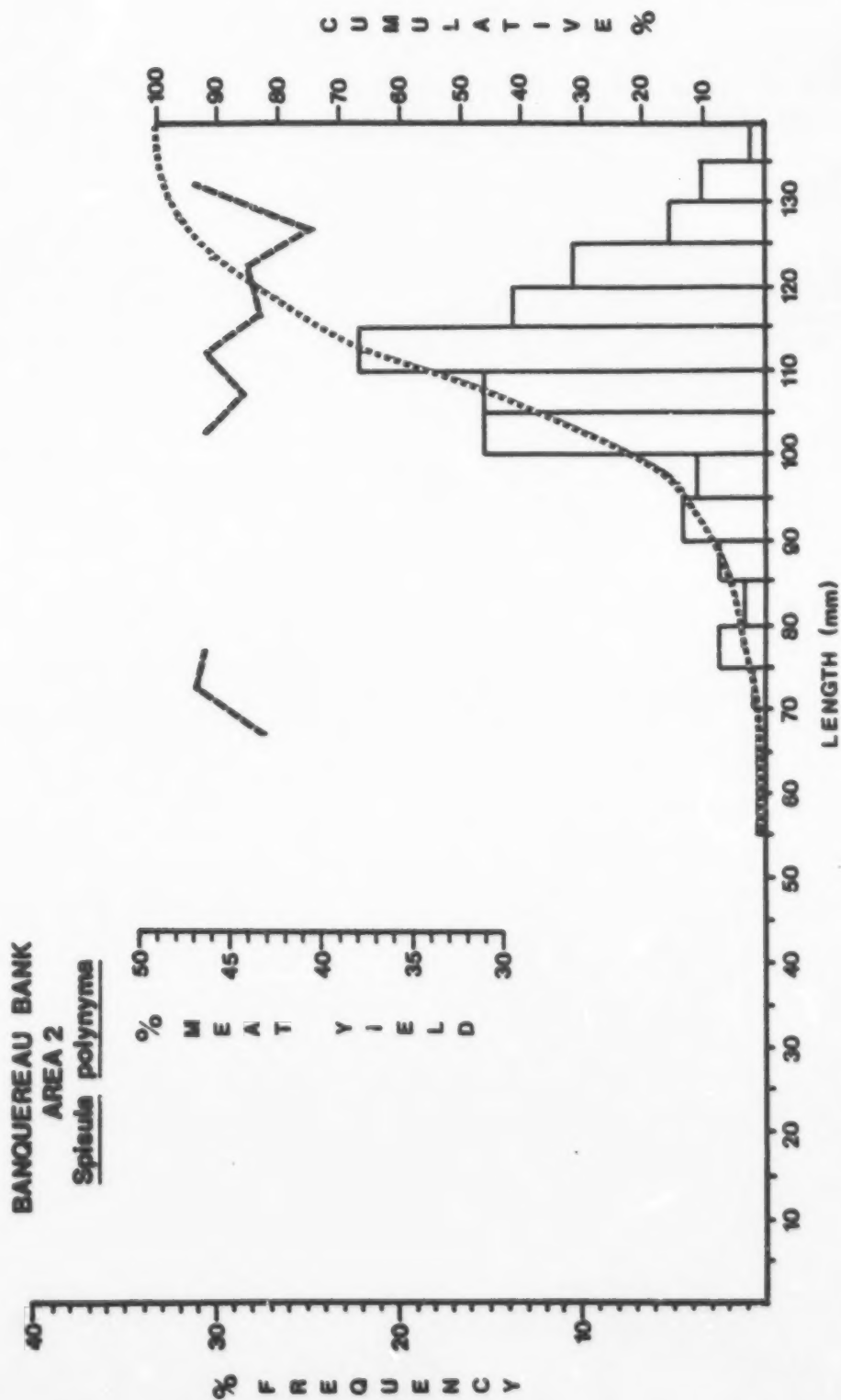


Fig. 19. Length frequency ($n=380$), cumulative percent frequency, and percent meat yield ($n=63$) for each 5 mm size class of S. polynyma in Area 2 of Banquereau Bank. No meat yield data were available between 80-105 mm.

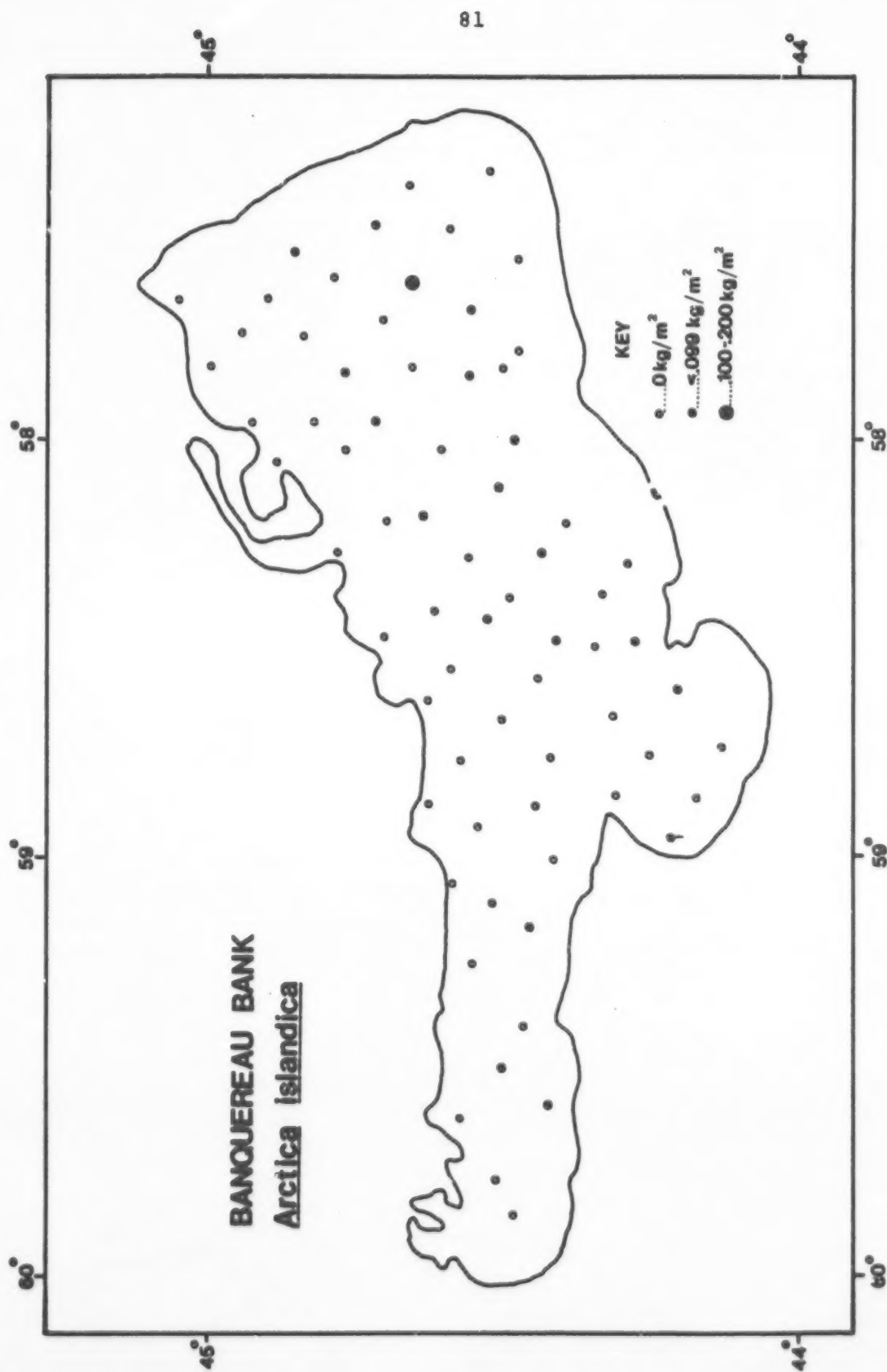


Fig. 20. Location of stations surveyed on Banquereau bank in 1981-1982 showing densities (kg/m²) of A. islandica.

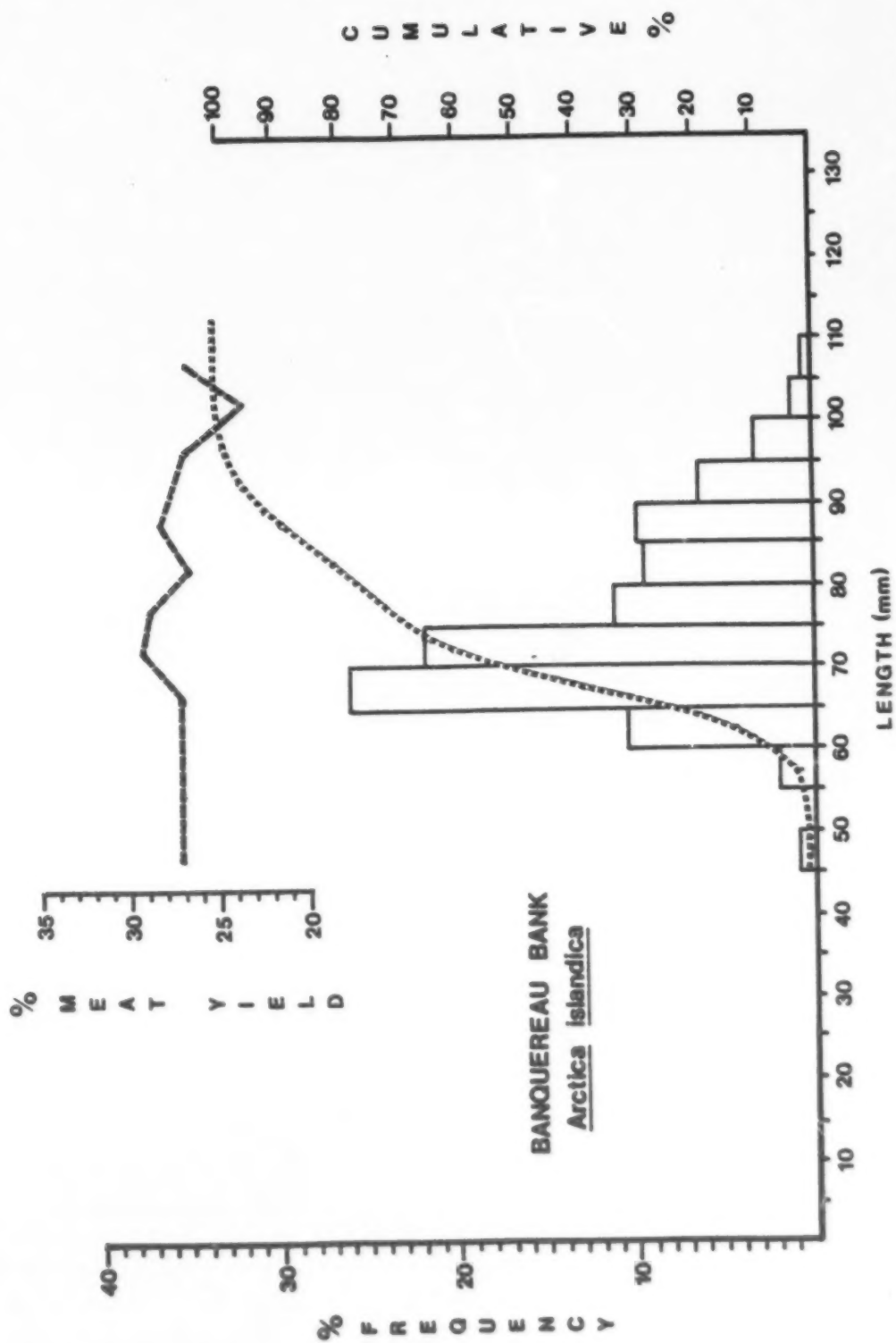


Fig. 21. Length frequency ($n=461$), cumulative percent frequency, and percent meat yield for each 5 mm size class of *A. islandica* on Banquereau Bank.

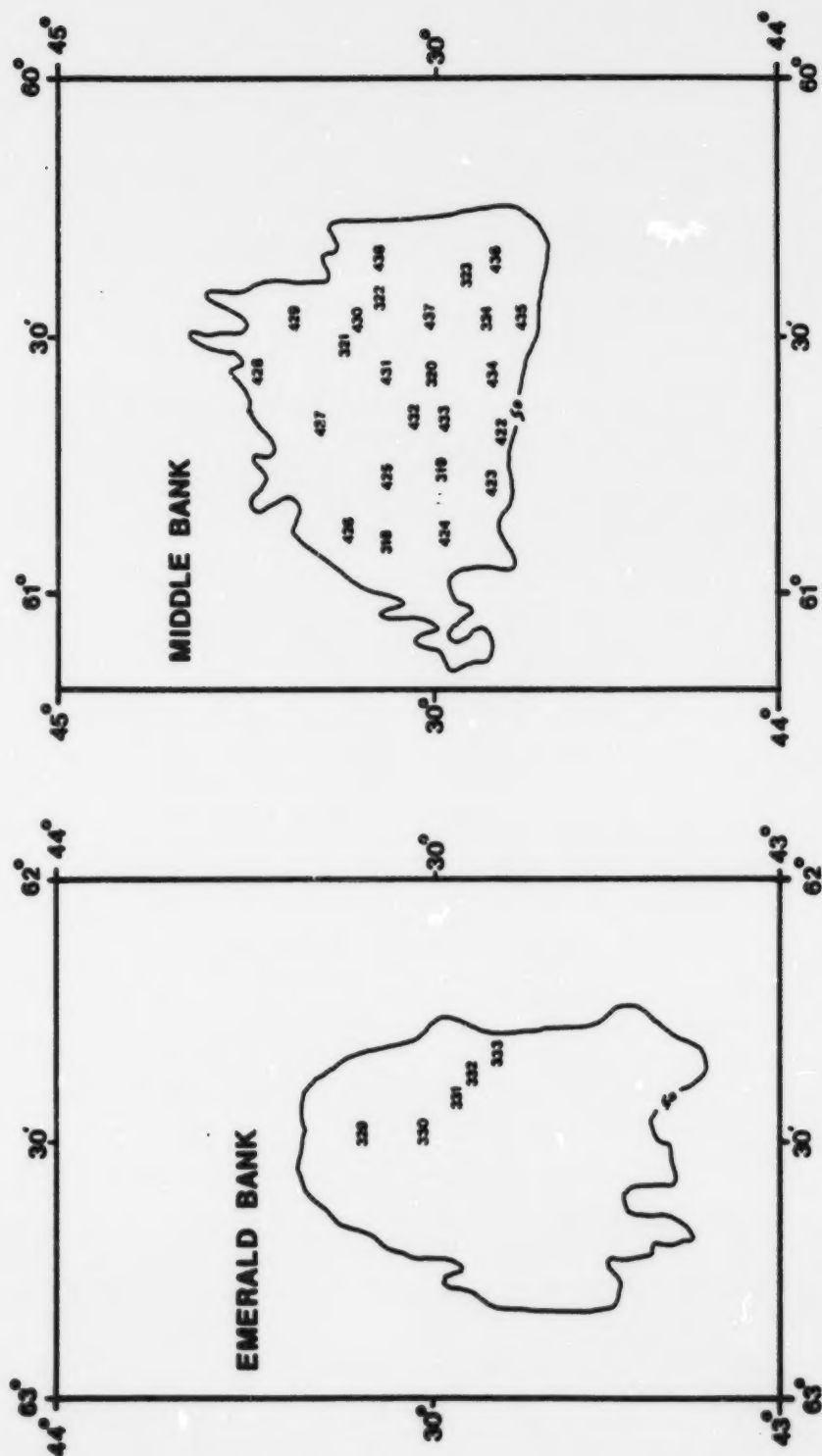
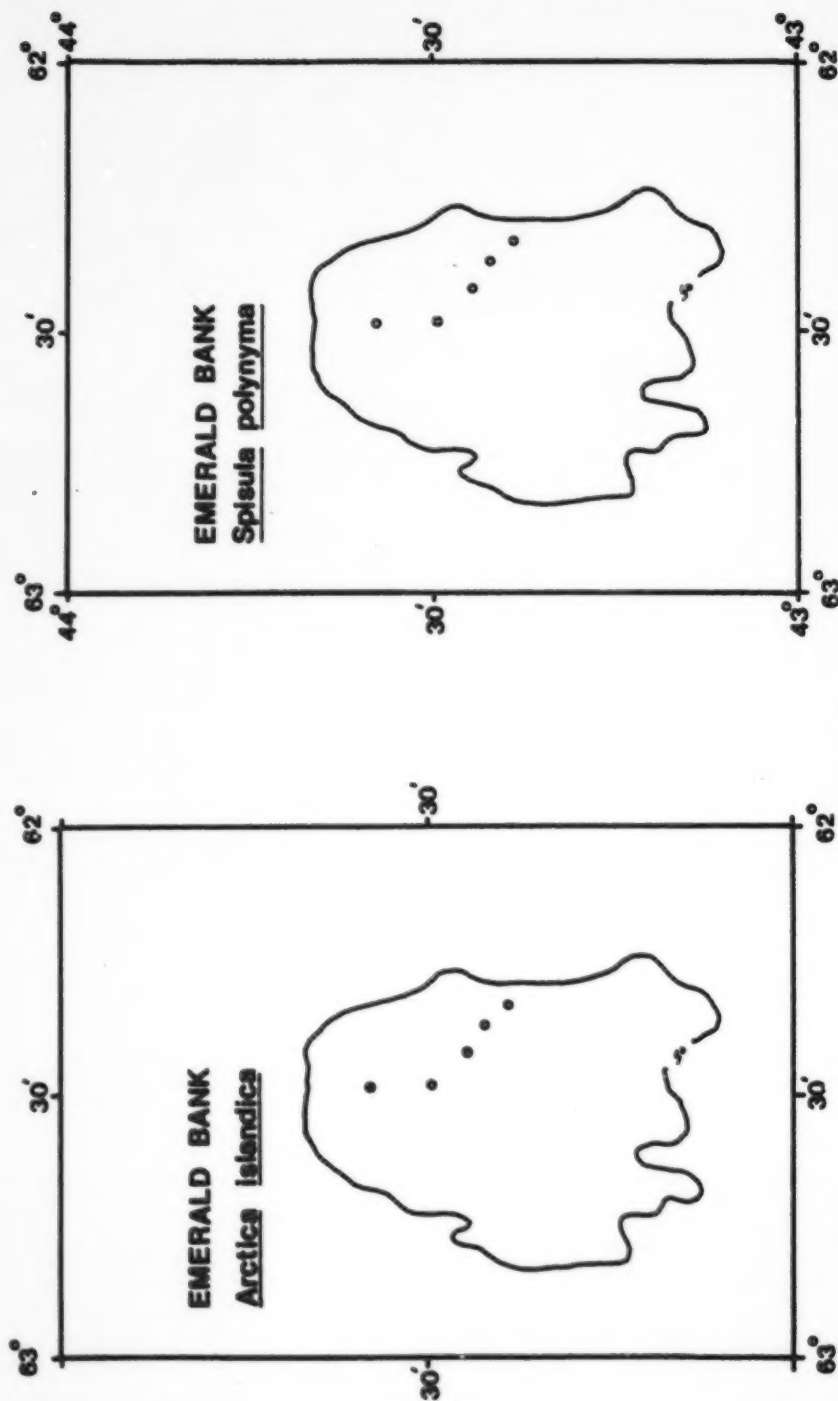


Fig. 22a. Location of stations surveyed on Emerald Bank in 1981.

Fig. 22b. Location of stations surveyed on Middle Bank in 1981-1982.



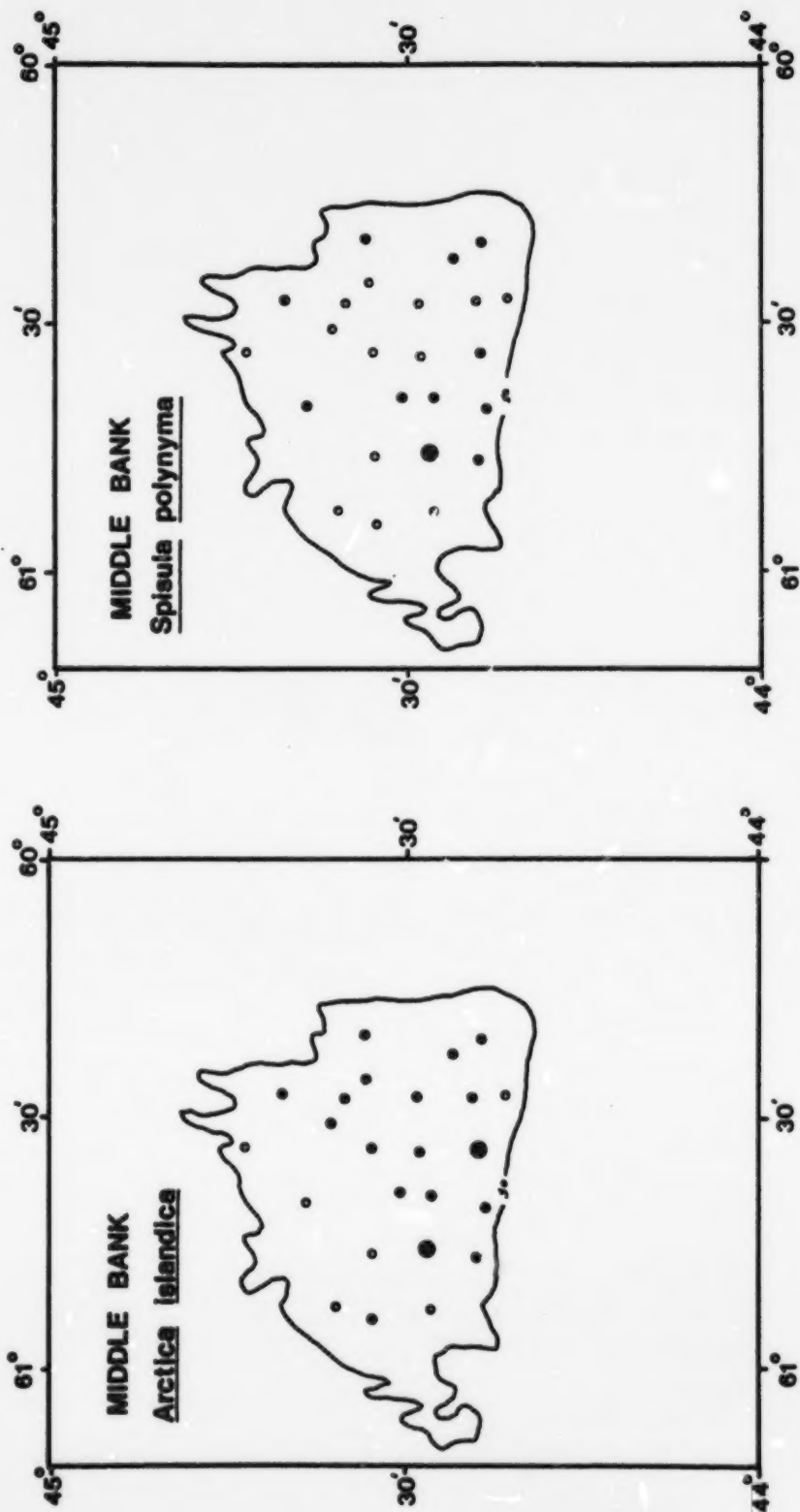


Fig. 24a. Location of stations surveyed on Middle Bank₂ showing densities (kg/m²) of A. islandica.

Fig. 24b. Location of stations surveyed on Middle Bank₂ showing densities (kg/m²) of S. polynyma.

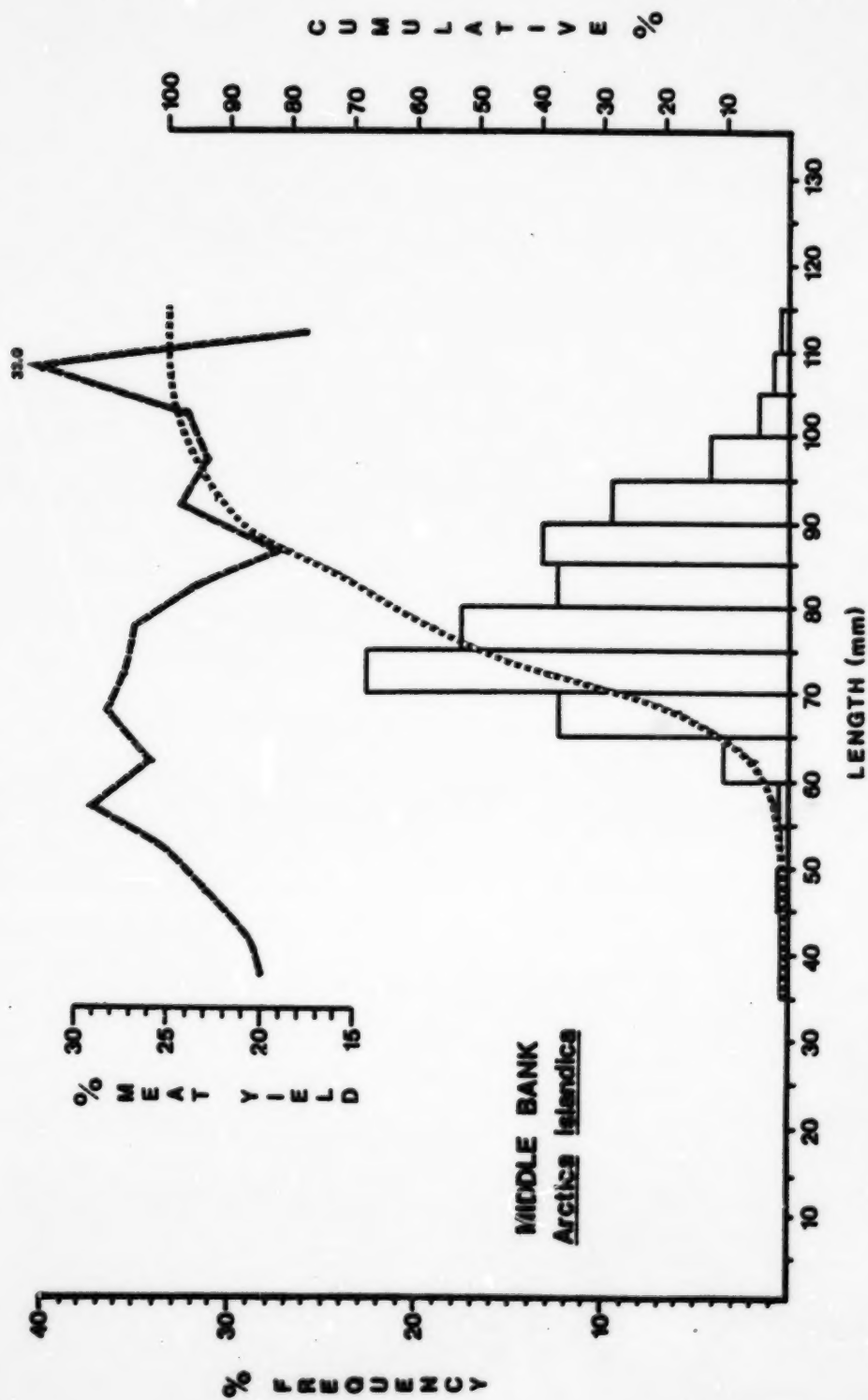


Fig. 25. Length frequency (n=894), cumulative percent frequency, and percent meat yield (n=334) for each 5 mm size class of *A. Islandica* on Middle Bank.

2. The first group of 10 cases, 100-109, are the first 10 cases of the first group of 100 cases, 100-199, and the second group of 10 cases, 200-209, are the first 10 cases of the second group of 100 cases, 200-299.



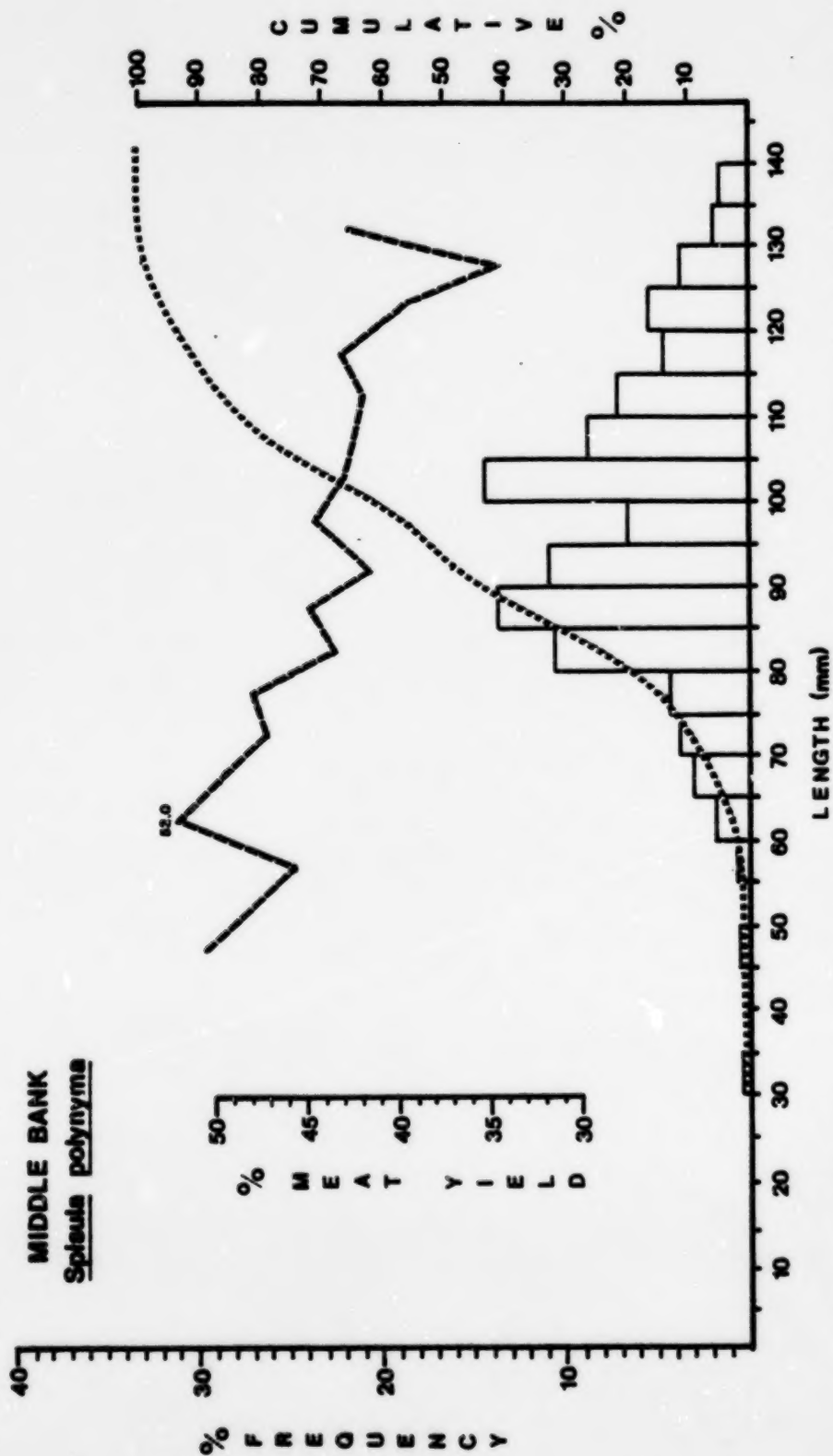


Fig. 26. Length frequency ($n=583$), cumulative percent frequency, and percent meat yield ($n=57$) for each 5 mm size class of S. polynyma on Middle Bank.



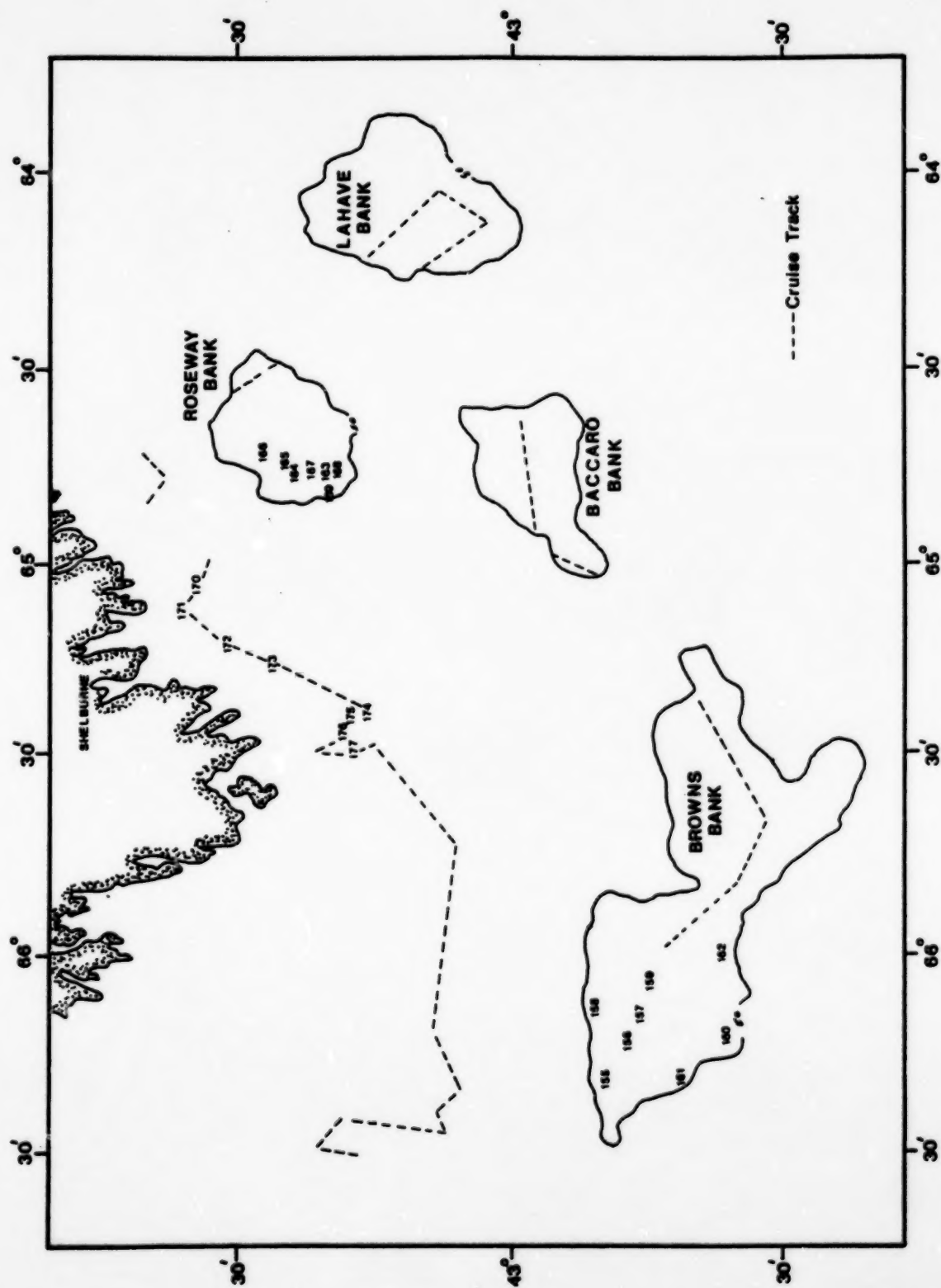


Fig. 27. Location of stations surveyed on Browns Bank, Roseway Bank, and the near-shore area in 1980.

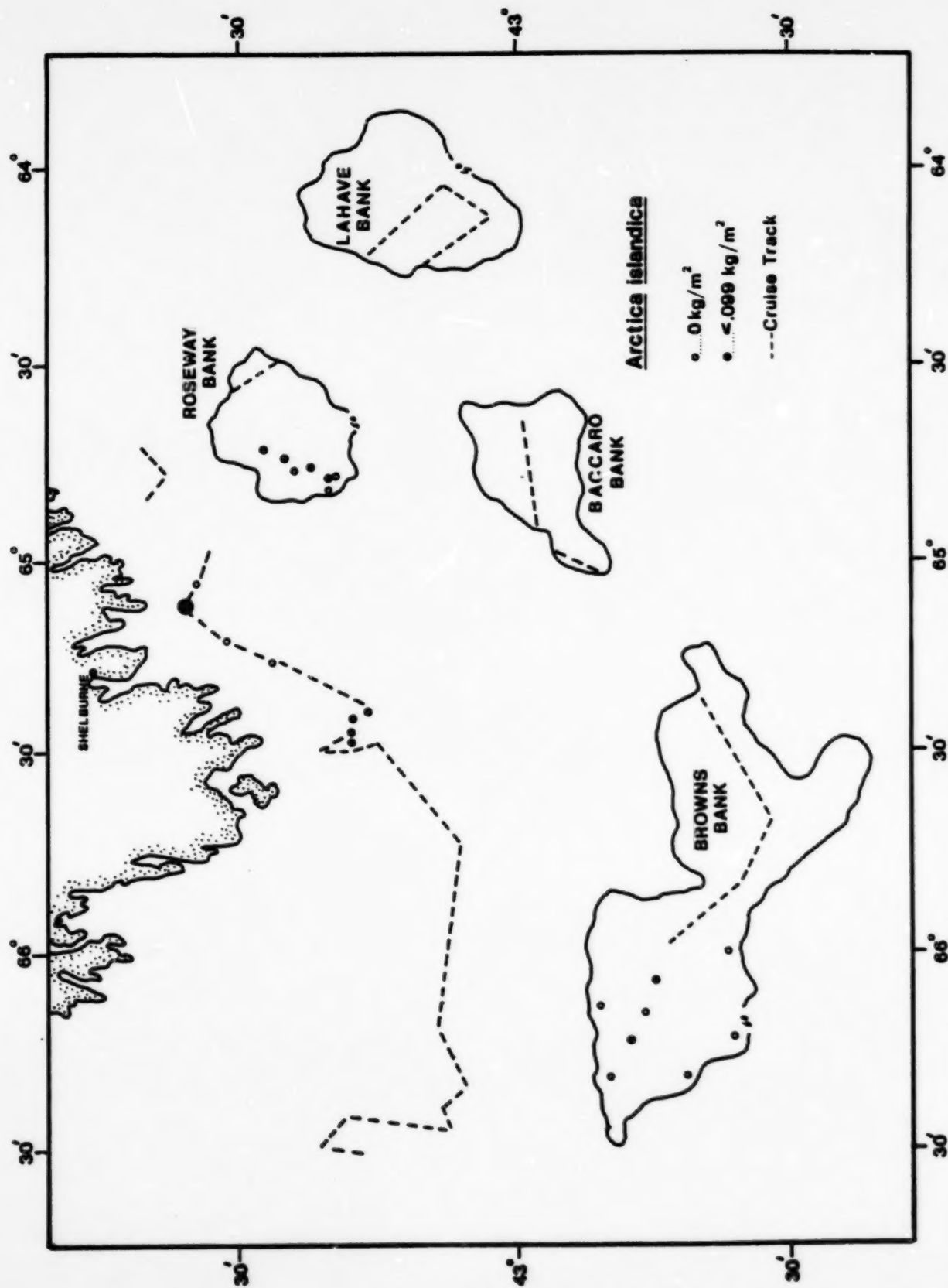


Fig. 28. Location of stations surveyed on Browns Bank, Roseway Bank, and the near-shore area showing densities (kg/m²) of *A. islandica*.

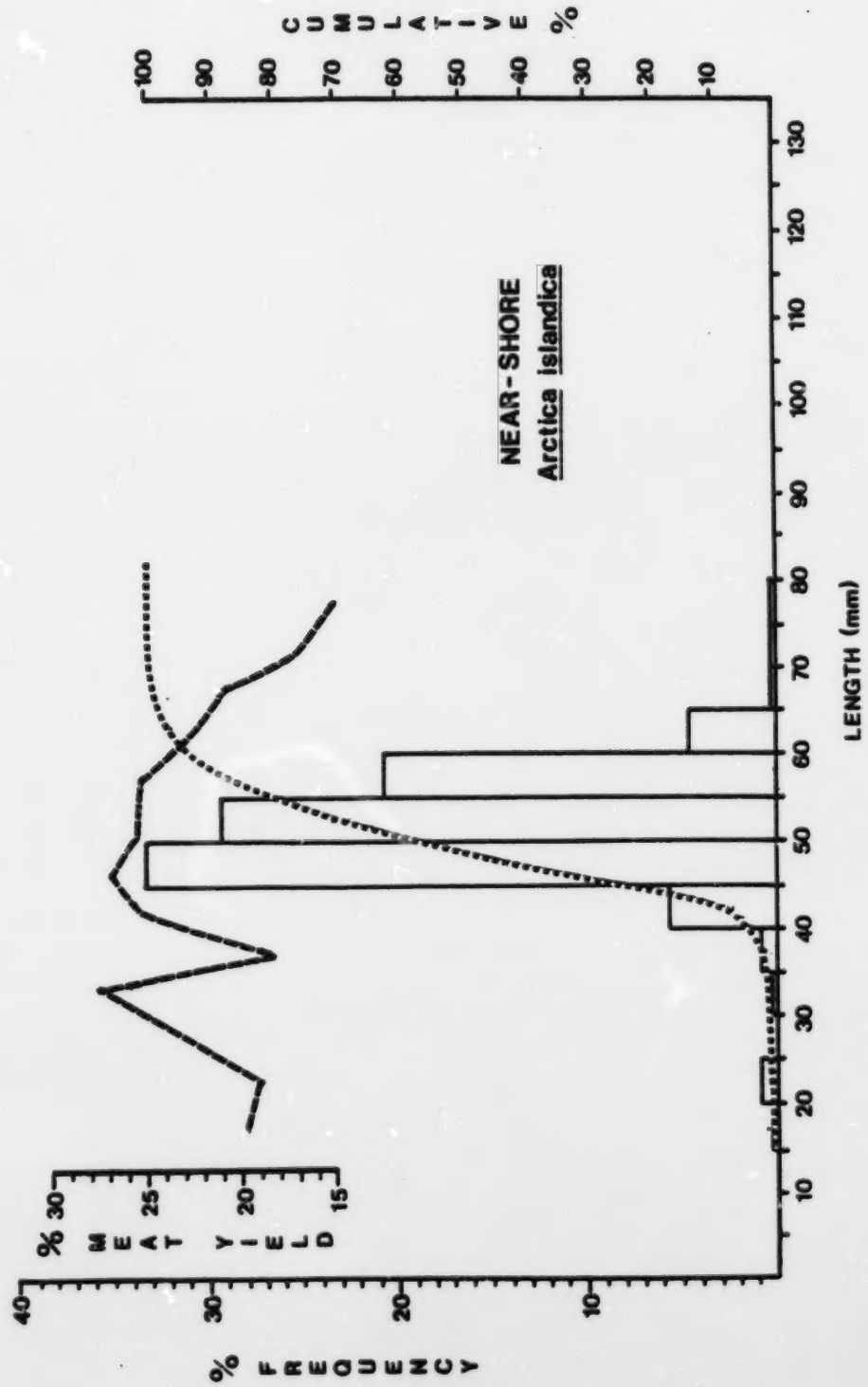


Fig. 29. Length frequency ($n=221$), cumulative percent frequency, and percent meat yield ($n=218$) for each 5 mm size class of A. islandica on the near-shore area.

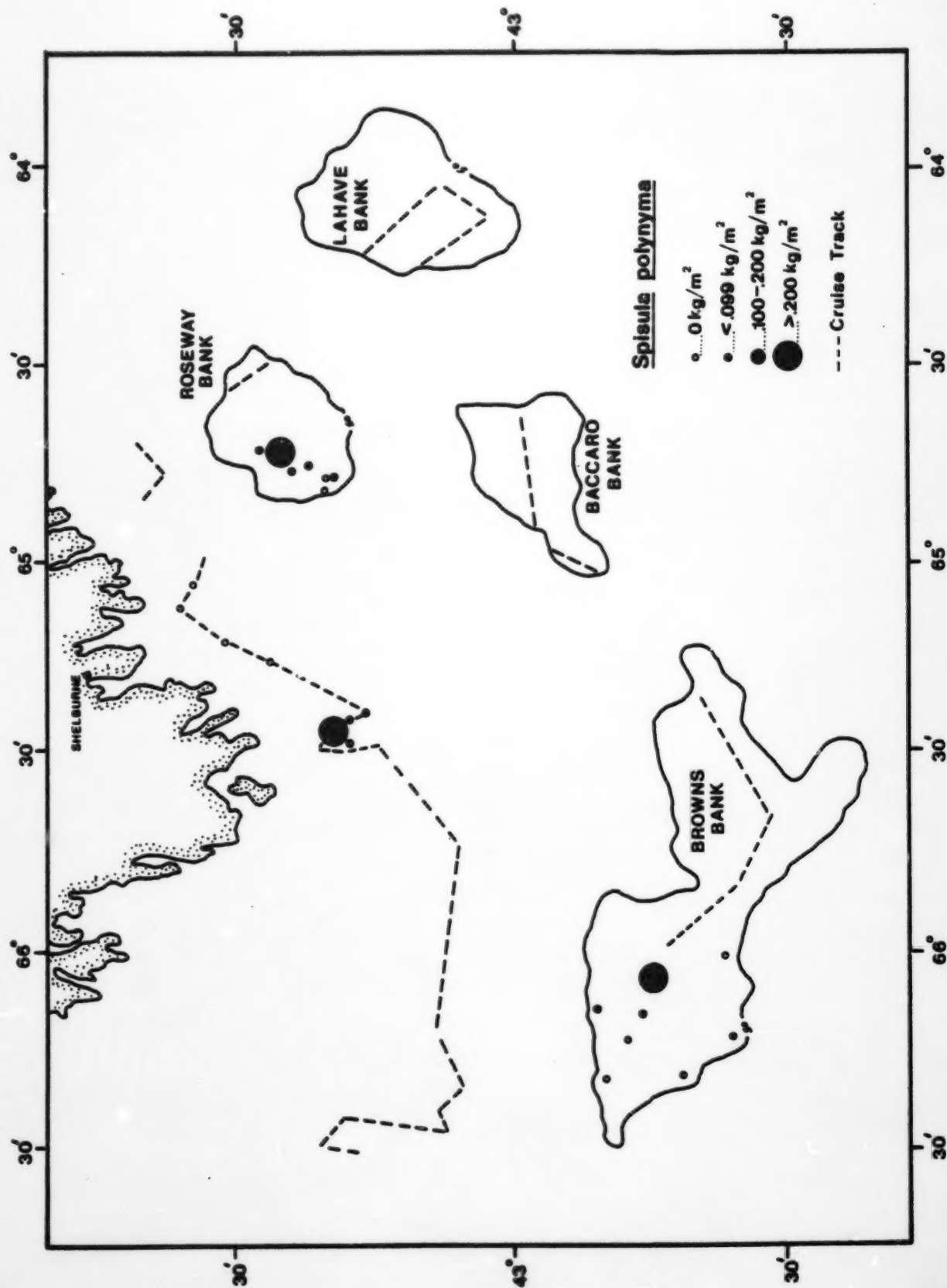


Fig. 30. Location of stations surveyed on Browns Bank, Roseway Bank, and the near-shore area showing densities (kg/m²) of *S. polynyma*.

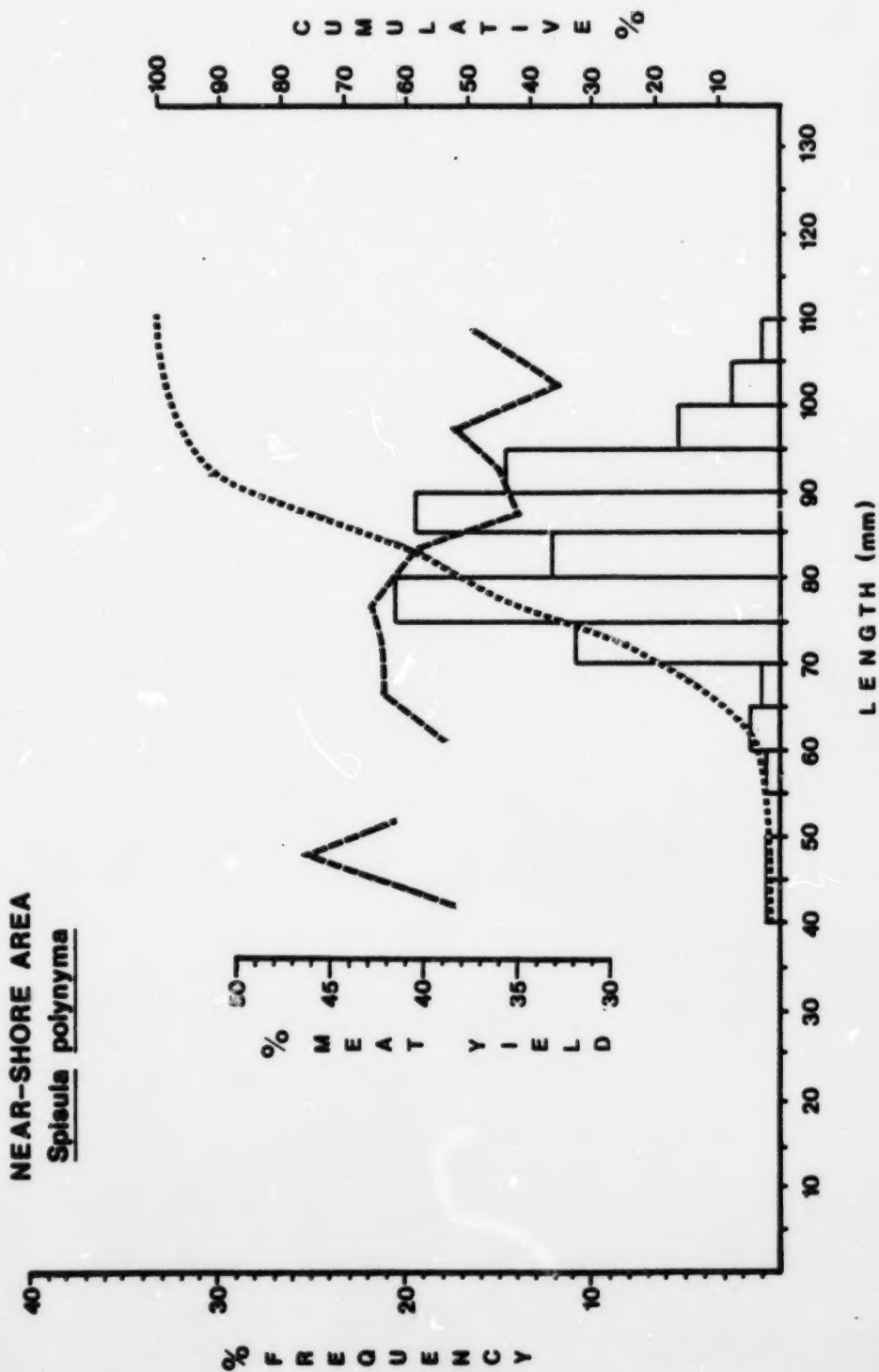


Fig. 31. Length frequency ($n=130$), cumulative percent frequency, and percent meat yield ($n=95$) for each 5 mm size class of S. polynyma on the near-shore area. No meat yield data were available between 50-60 mm.

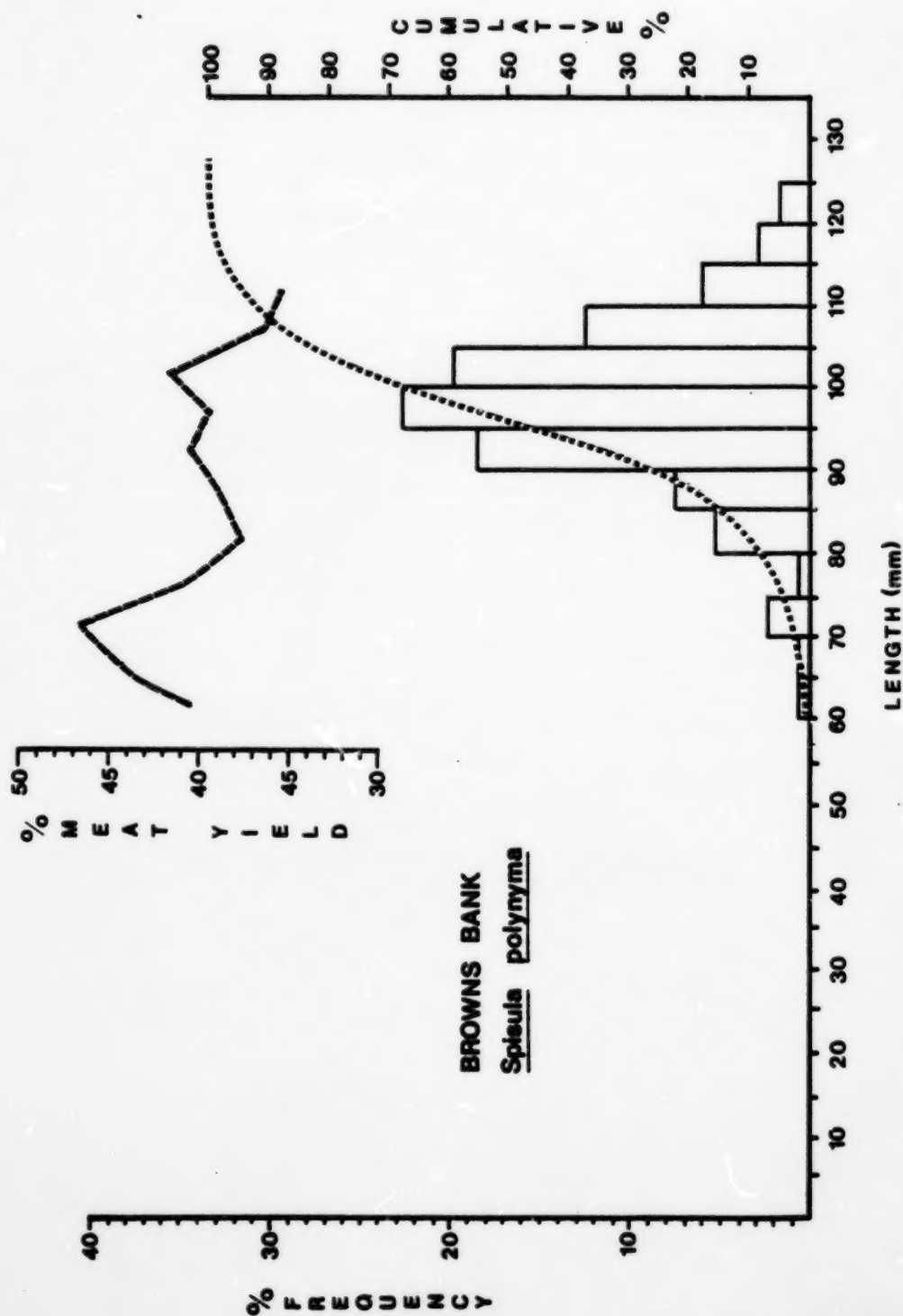


Fig. 32. Length frequency ($n=172$), cumulative percent frequency, and percent meat yield ($n=38$) for each 5 mm size class of S. polynyma on Browns Bank.

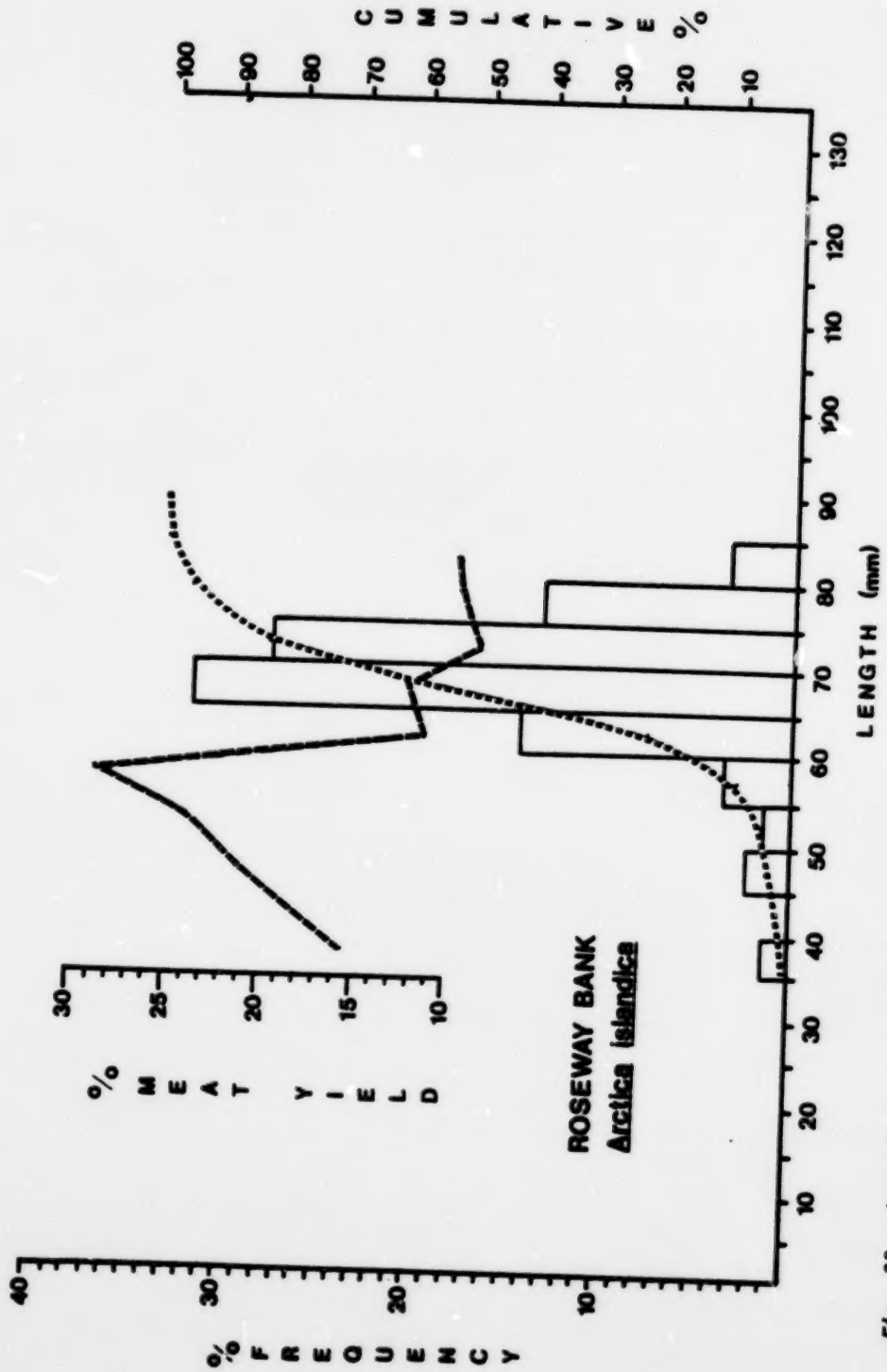


Fig. 33. Length frequency ($n=83$), cumulative percent frequency, and percent meat yield for each 5 mm size class of *A. islandica* on Roseway Bank.

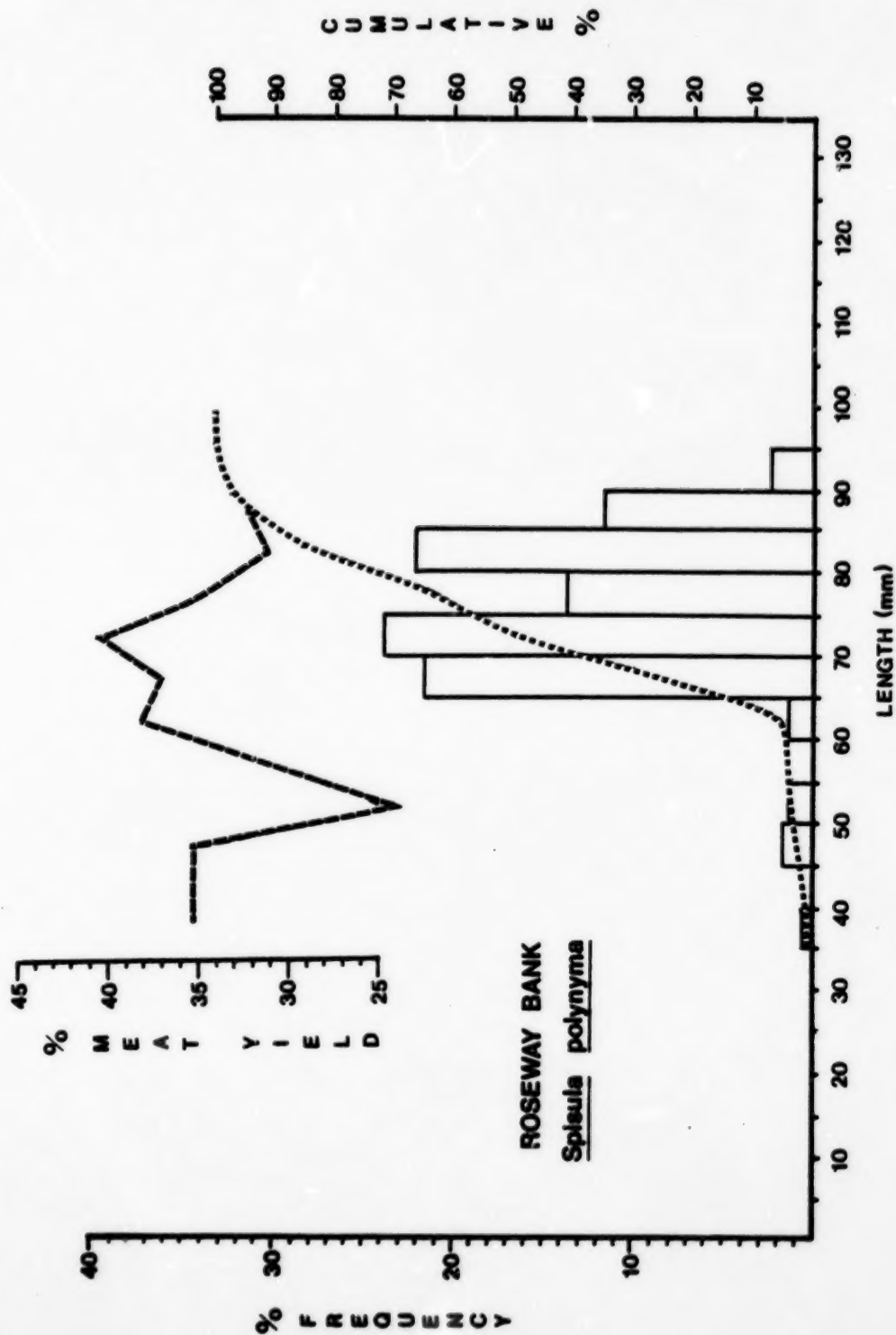


Fig. 34. Length frequency ($n=180$), cumulative percent frequency, and percent meat yield ($n=35$) for each 5 mm size class of S. polynyma on Roseway Bank.

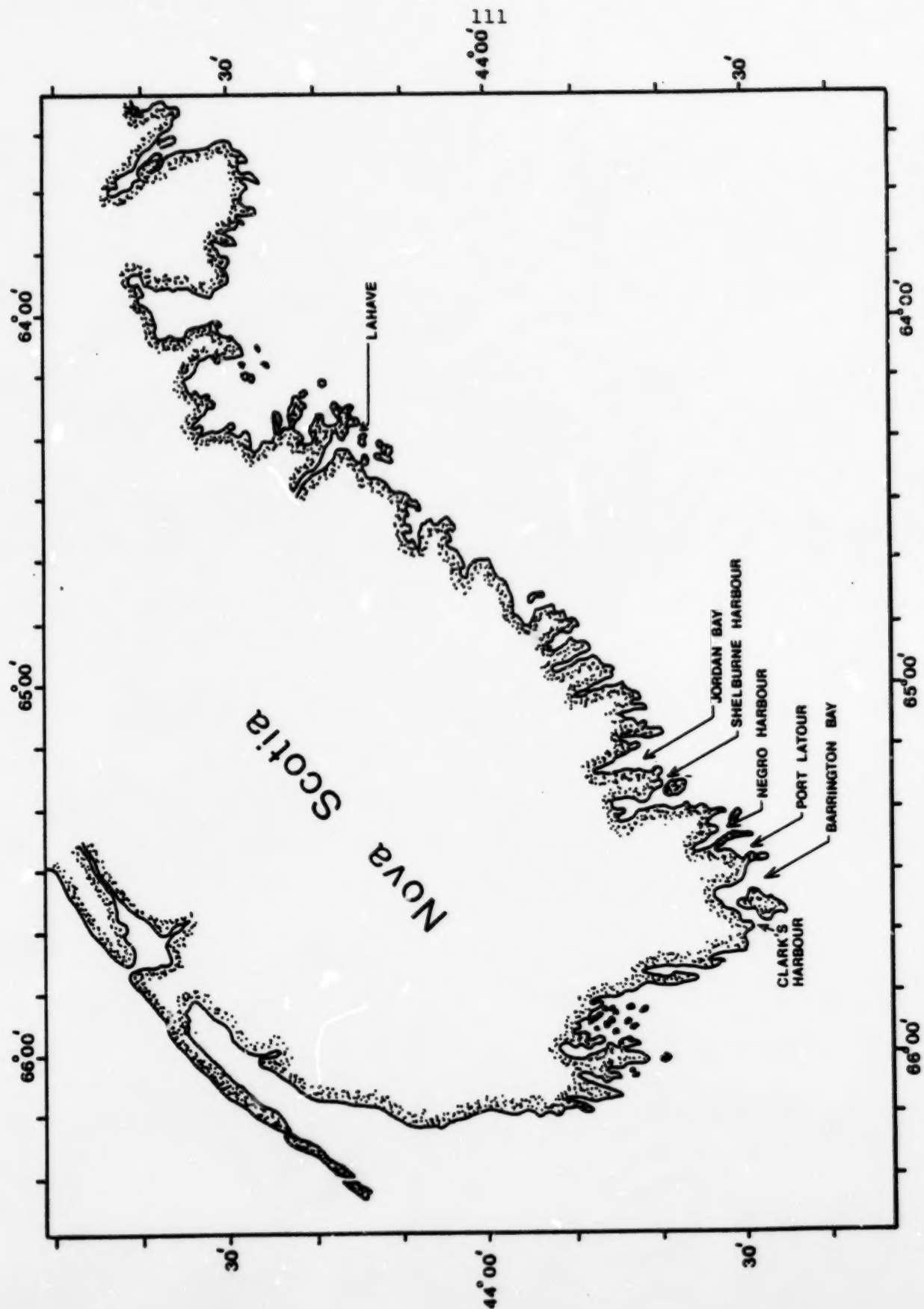


Fig. 35. Location of inshore areas having the greatest potential for commercial development of A. islandica.



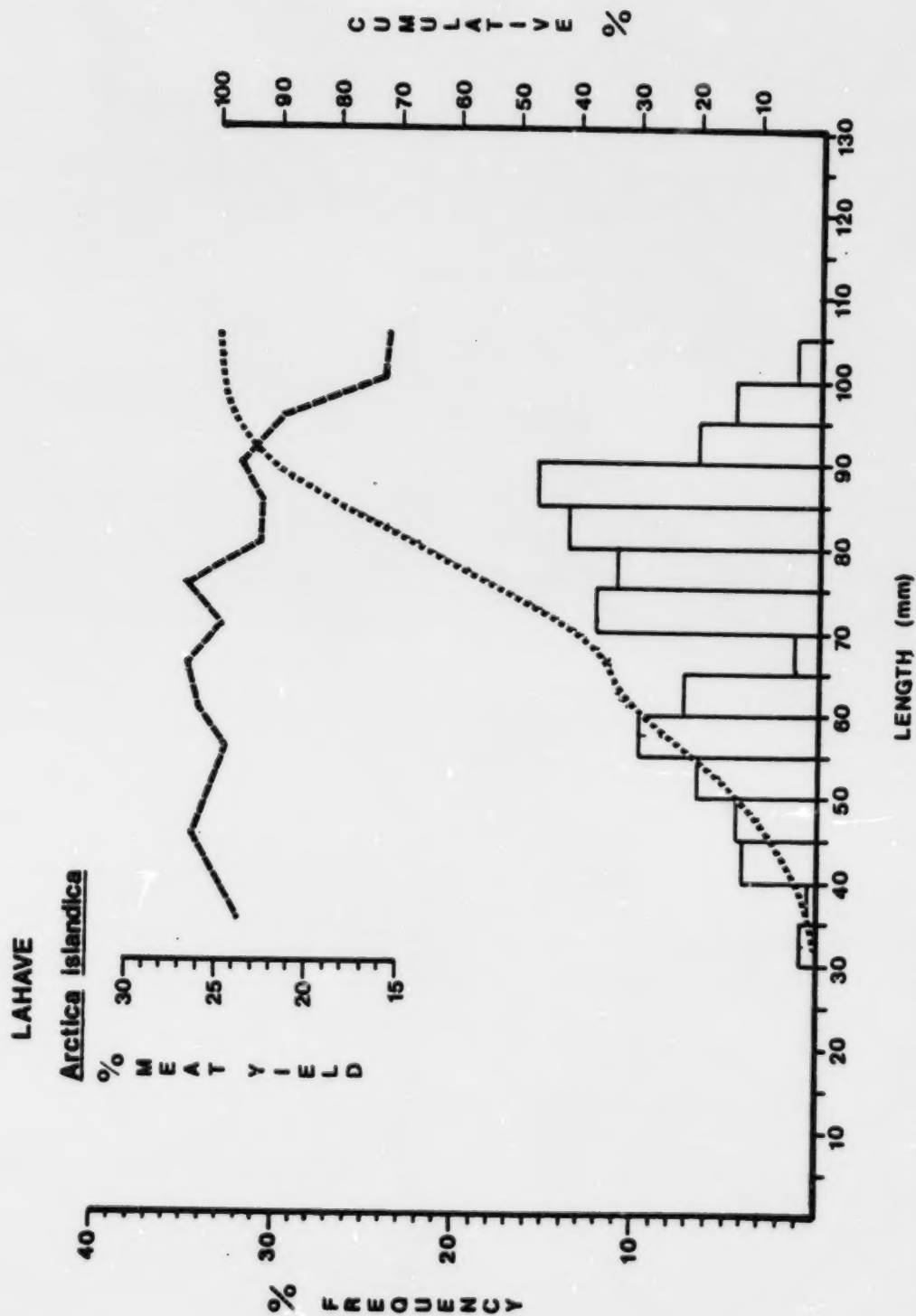


Fig. 36. Length frequency ($n=245$), cumulative percent frequency, and percent meat yield ($n=58$) for each 5 mm size class of A. islandica from the 1982 LaHave survey.

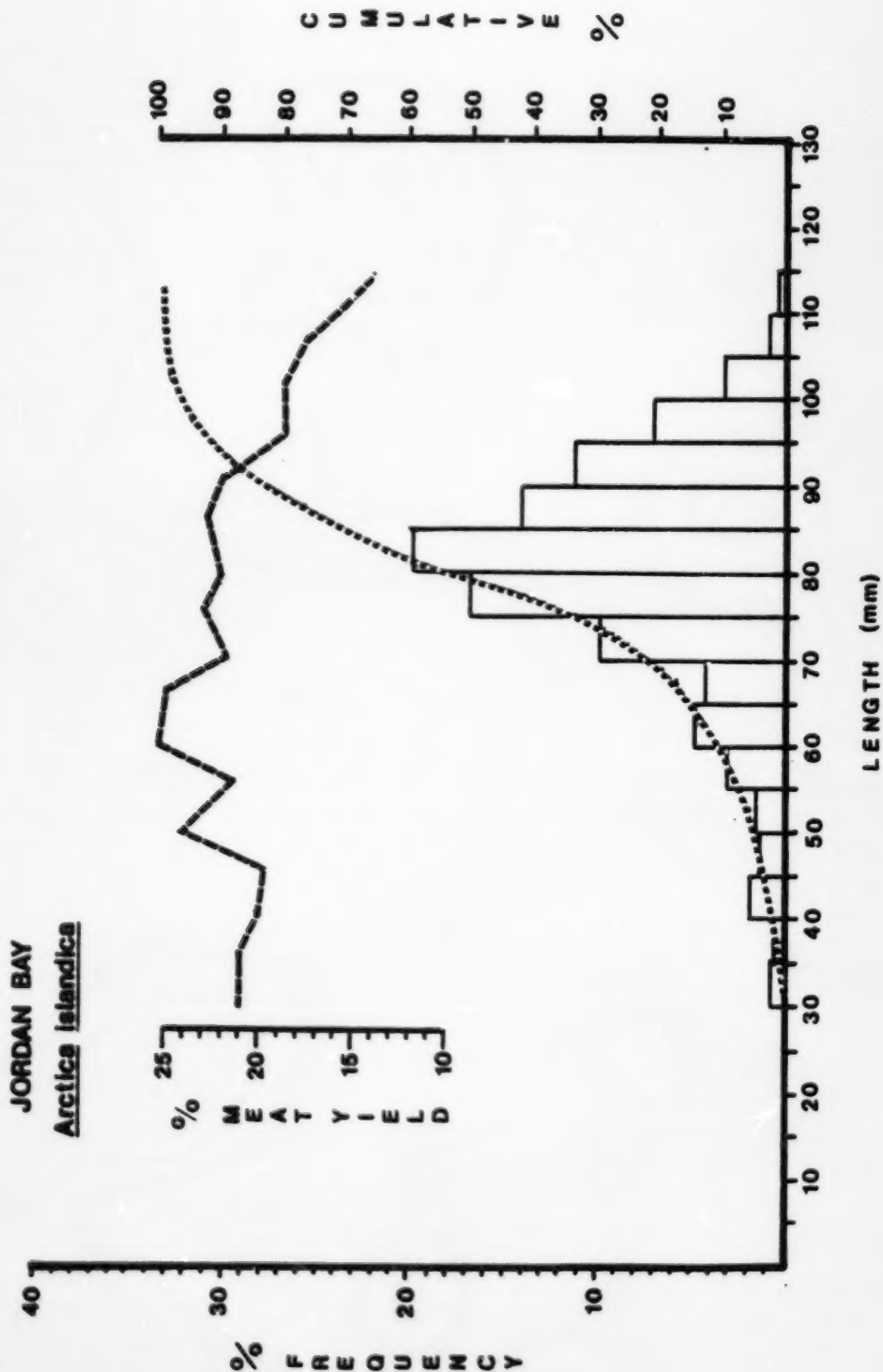


Fig. 37. Length frequency ($n=1072$), cumulative percent frequency, and percent meat yield ($n=315$) for each 5 mm size class of A. islandica from the 1981 Jordan Bay survey.

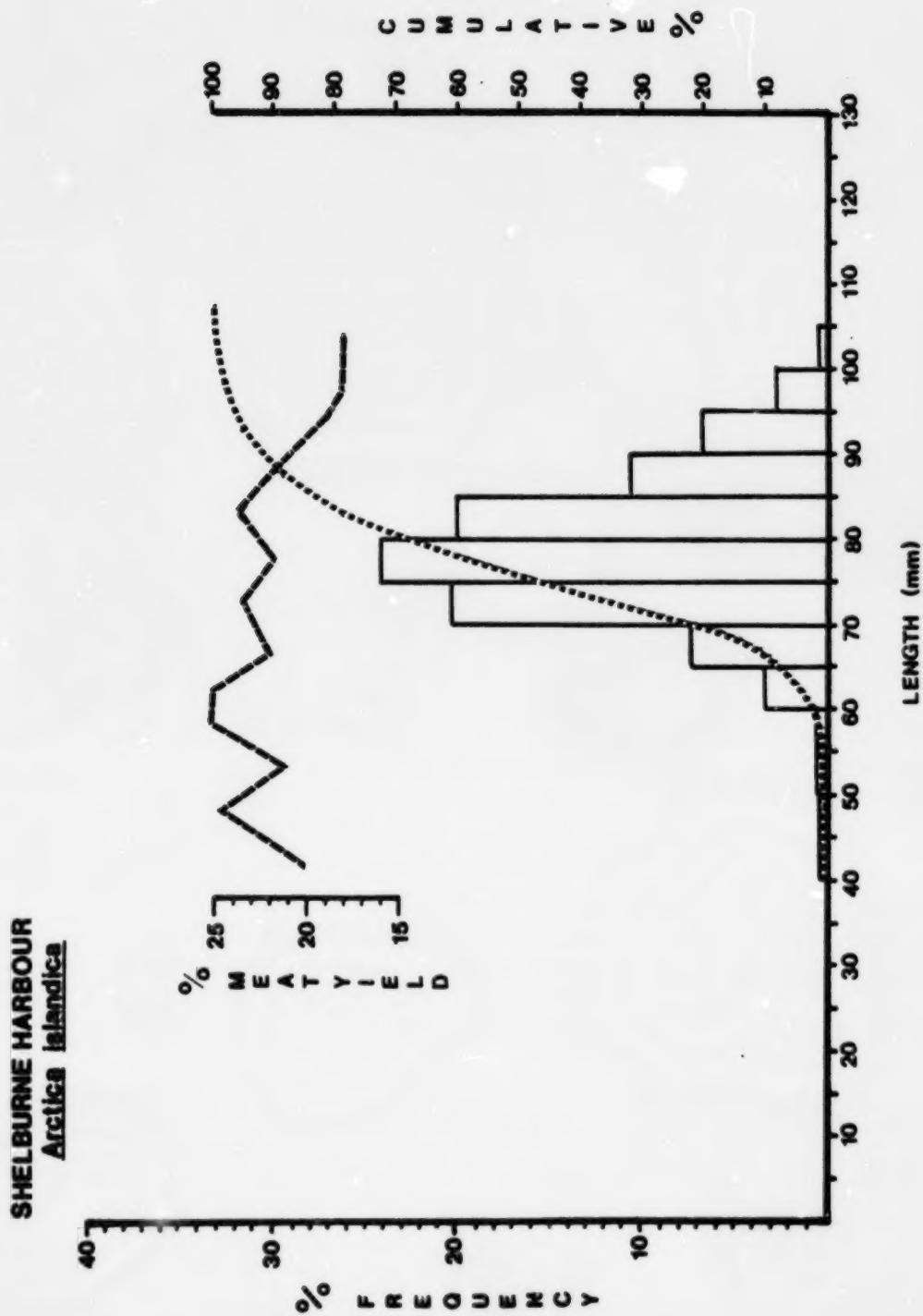


Fig. 38. Length frequency ($n=2204$), cumulative percent frequency, and percent meat yield ($n=261$) for each 5 mm size class of *A. islandica* from the 1982 Shelburne Harbour survey.

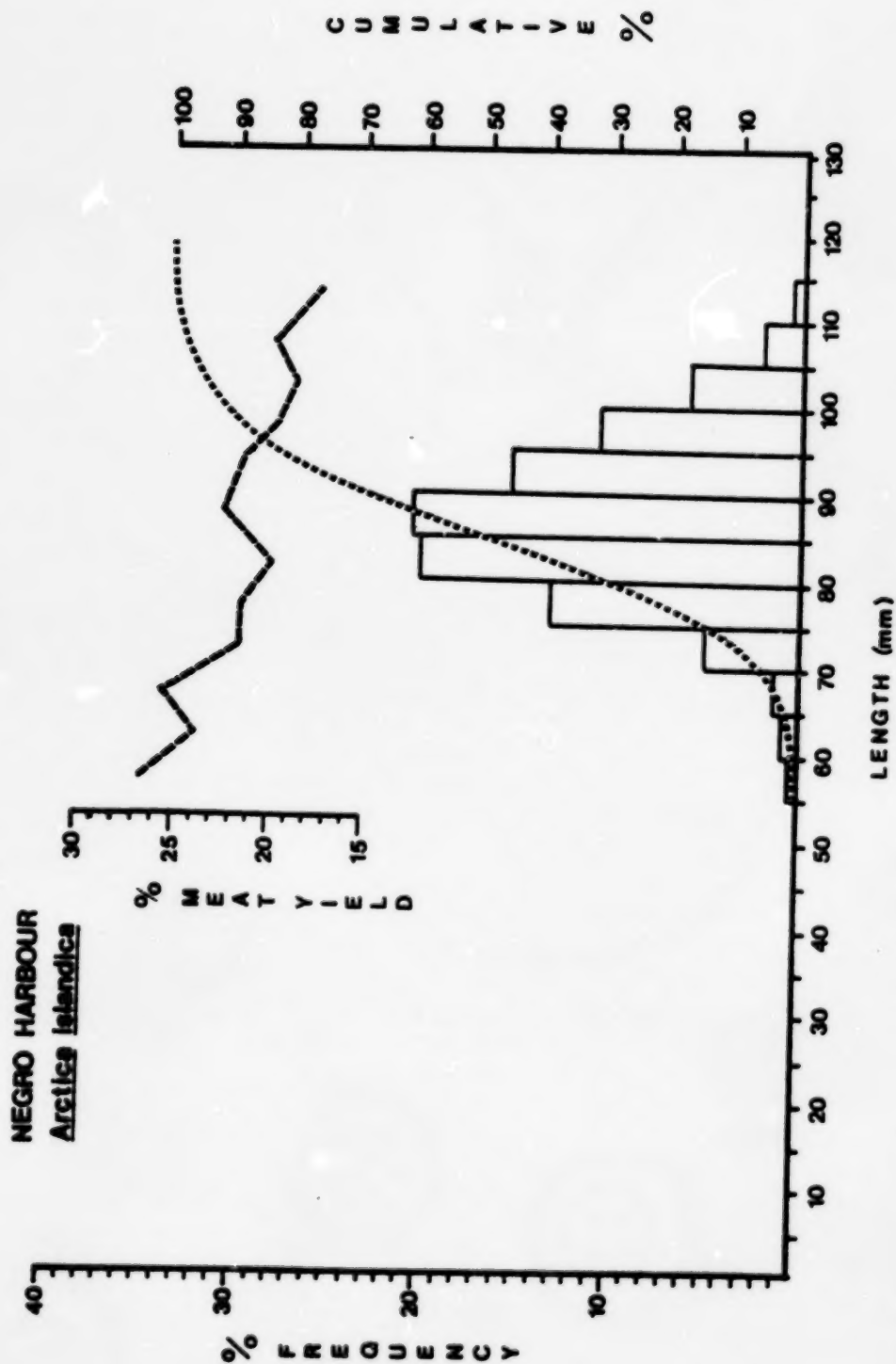


Fig. 39. Length frequency ($n=453$), cumulative percent frequency, and percent meat yield ($n=93$) for each 5 mm size class of A. islandica from the 1982 Negro Harbour survey.

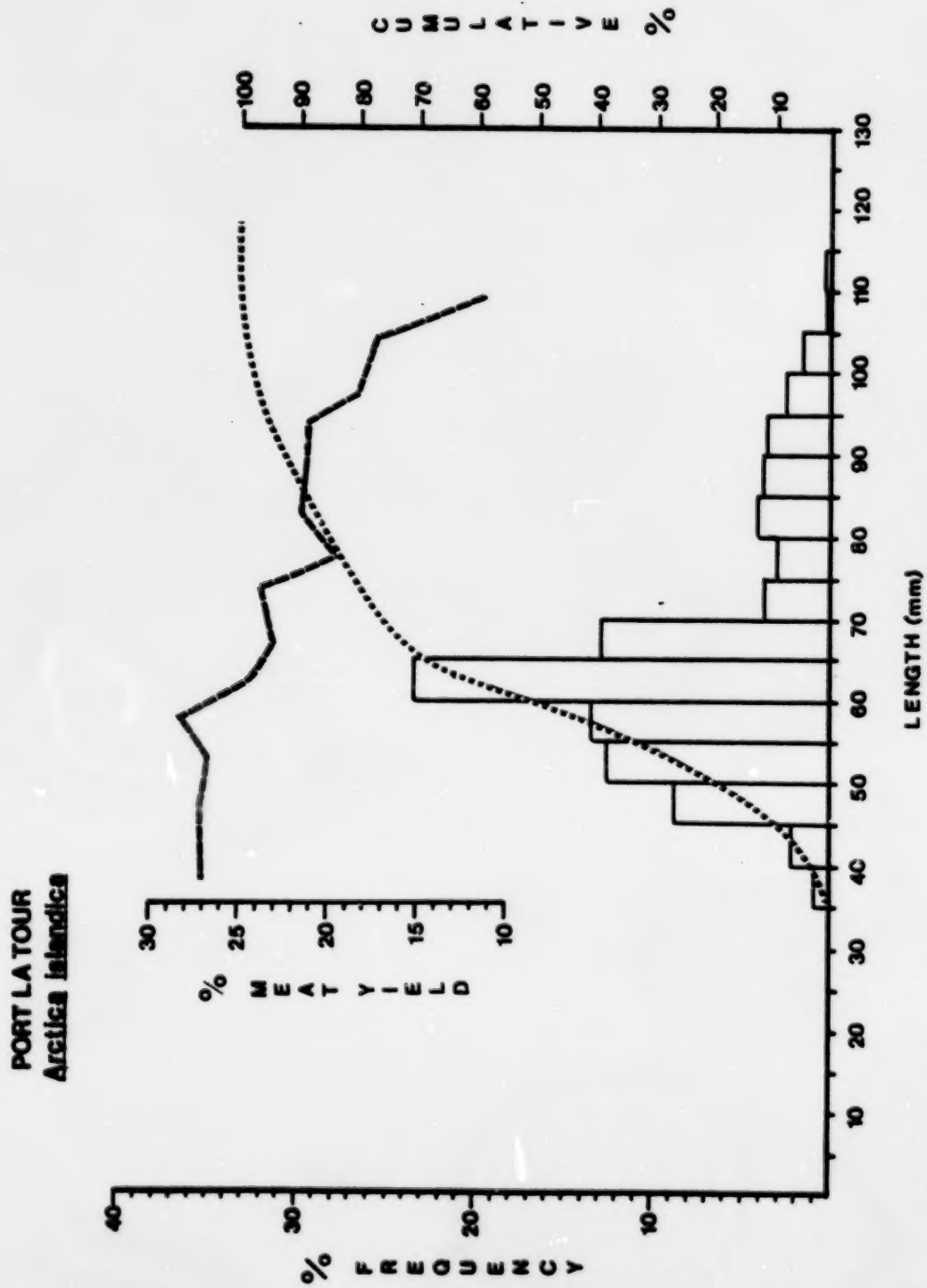


Fig. 40. Length frequency (n=1289); cumulative percent frequency, and percent meat yield (n=172) for each 5 mm size class of *A. islandica* from the 1981 and 1982 Port LaTour surveys.

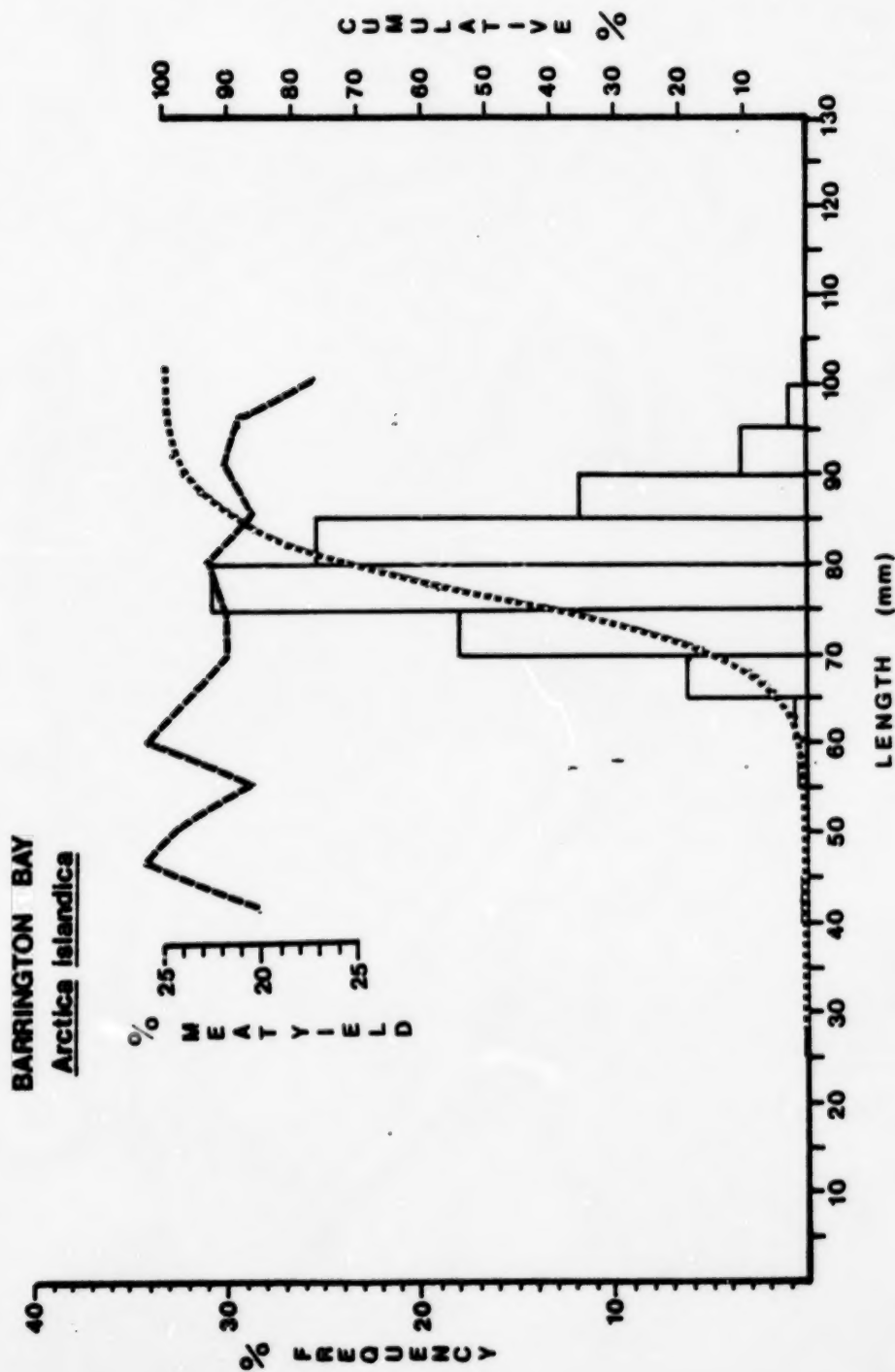


Fig. 41. Length frequency ($n=946$), cumulative percent frequency, and percent meat yield ($n=148$) for each 5 mm size class of *A. islandica* from the 1981 Barrington Bay survey.

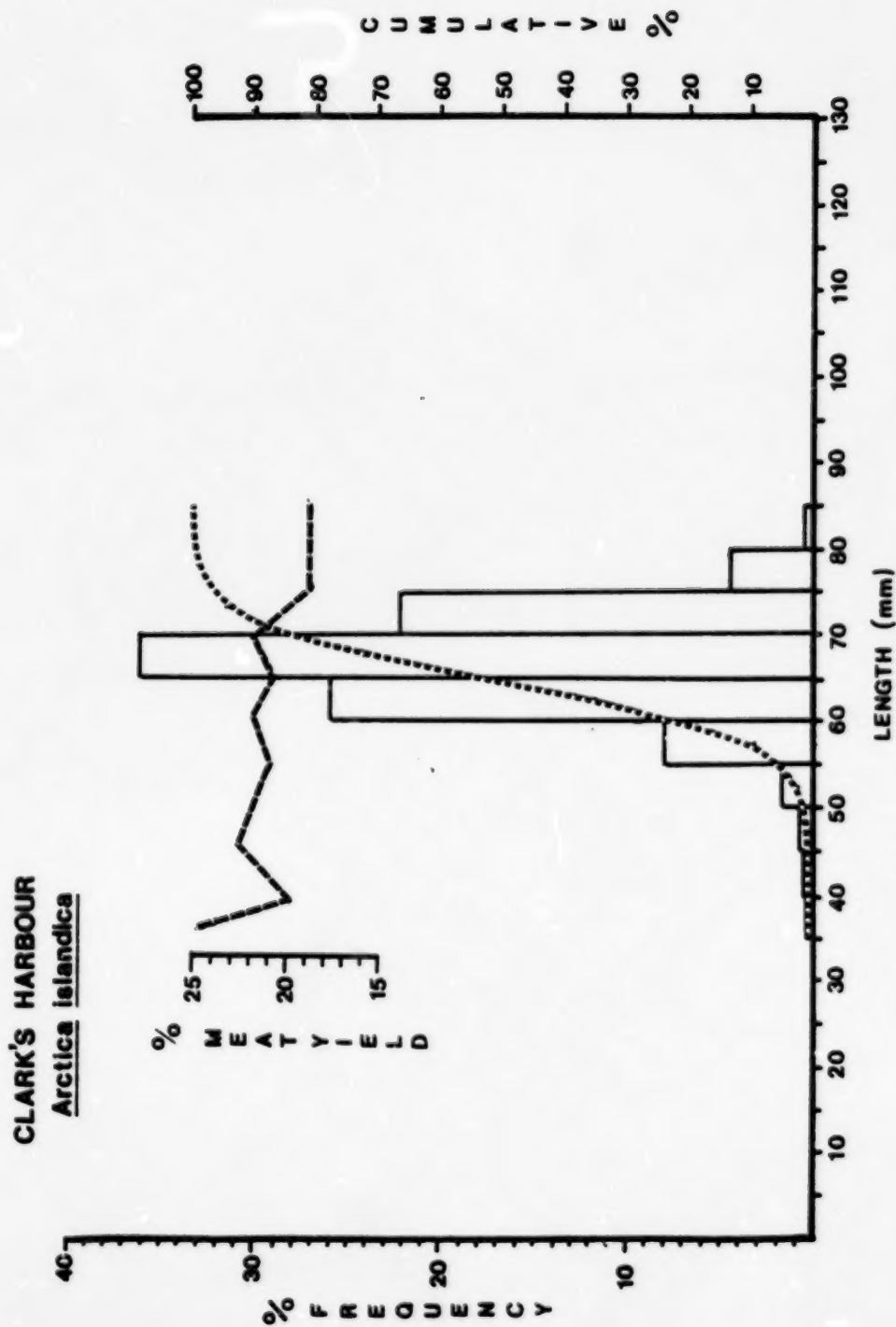


Fig. 42. Length frequency (n=2145), cumulative percent frequency, and percent meat yield (n=201) for each 5 mm size class of A. islandica from the 1982 Clark's Harbour survey.